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No. III.—MARCH, 1890.

ORIGINAL ARTICLES.

I.—Notes on the Palæontology of Western Australia.

Introductory.

A PART of the fossils described in the accompanying paper were presented to the British Museum (Natural History) by the late Mr. Edward T. Hardman, F.G.S., F.R.G.S.I., in December, 1886;[1] having been collected by him during his exploration of the Kimberley District of Western Australia, in 1883. Some additional specimens, forming a part of this collection, have been obligingly forwarded to me by Professor Edward Hull, LL.D., F.R.S., Director of the Geological Survey of Ireland; having been found, since Mr. Hardman's death, in the Survey Office, Dublin.

A collection of Carboniferous Fossils has since been received from Mr. Harry P. Woodward, F.G.S., F.R.G.S., the Government Geologist for Western Australia, which were obtained by him whilst exploring the Gascoyne River District and the Victoria District of the Irwin River. I have, moreover, been favoured with a fine slab of sandstone, full of shells of *Spirifera lata*, M'Coy (Plate VI.), from the Carboniferous formation of the Lyons River, Western Australia; collected by the Hon. John Forrest, C.M.G., and forwarded to me by the Rev. J. G. Nicolay, of Fremantle, to whom I am already indebted for the opportunity of describing the spine of *Edestus Davisii* from the Carboniferous of the same region (see Geol. Mag. 1886, Dec. III. Vol. III. pp. 1–7, Pl. I.).

The descriptions of the Brachiopoda, Mollusca, etc., have been most carefully drawn up by Mr. Arthur H. Foord, F.G.S. (late Assistant-Palæontologist to the Geological Survey of Canada); a brief note on the Plant-remains is given by Mr. R. Kidston, F.R.S.E., F.G.S. A description of the Stromatoporoids in the Collection by Prof. H. Alleyne Nicholson, M.D., F.G.S., and of the Corals and Polyzoa by Dr. George J. Hinde, F.G.S., will follow.

On behalf of my son (Mr. Harry P. Woodward) I have to express my thanks to these gentlemen for their most valuable contributions towards the description of the fossils of Western Australia, and to my friend Mr. Robert Etheridge, jun., Palæontologist to the Australian Museum, Sydney, N. S. Wales, for kindly allowing me to consult the proofs of plates and explanations thereof in MS., of his as yet unpublished work, with Mr. R. L. Jack, F.G.S. (Government Geologist), on the Fossils of Queensland, Australia, many of which bear a very close resemblance to those of Western Australia.

British Museum (Natural History),
Cromwell Road, *Feb.* 15, 1890.

Henry Woodward.

[1] After the close of the Colonial Exhibition.

Description of Fossils from the Kimberley District,[1] Western Australia.

By Arthur H. Foord, F.G.S.

(PLATES IV. and V.)

I. CAMBRIAN.

PTEROPODA.

Salterella Hardmani (Etheridge, Jun., MS.), sp.nov. Plate IV. Figs. 1, 1*a*, 1*b*.

Several of the tubes of this singular genus are exposed in section on the weathered (water-worn?) surface of a piece of limestone. The tubes are of an elongate conical form, rather rapidly tapering, and straight or slightly curved, the longest about 10 lines; each contains several smaller tubes one within the other, the last of these little hollow cones being the chamber of habitation. The shell is thick, and has consequently not been crushed, two or three of the inner tubes retaining their cylindrical form, as seen in the section Fig. 1*b*.

The present species is distinguished by its slowly tapering, smooth (?), and nearly straight shell. It most nearly resembles the *Salterella pulchella* of Billings (Geol. of Vermont, 1861, vol. ii. p. 955; also Palæoz. Foss. (Billings), 1861, vol. i. p. 18), carefully described and figured by Walcott in the Bulletin of the United States Geological Survey, No. 30, 1886, p. 144, pl. xiii. figs. 3, 3*a*.

The genus *Salterella* was regarded by Billings,[2] its author, as "allied to *Serpulites*," though he considered it "sufficiently distinct therefrom to constitute a distinct genus." He subsequently (Geol. of Canada, 1863, Appendix, p. 949) placed *Salterella* with the *Pteropoda*, and was followed in this by Dana (Manual of Geology, 1863, p. 187), Barrande (Syst. Sil. de la Bohême, 1867, vol. iii. pt. i. p. 137), and Zittel (Handbuch der Palæontologie, Abth. i. Lief. ii., 1882, p. 315).

The most instructive observations that have recently been made

[1] The following is Mr. E. T. Hardman's classification of the rocks in this District:—

AQUEOUS ROCKS.

Upper Tertiary.
Carboniferous.
a. Sandstone.
b. Limestone.
Devonian.

METAMORPHIC ROCKS.

Volcanic (probably Devonian).
Plutonic (Post-Silurian).

INTRUSIVE.

See his reports on the Geology of the Kimberley District, Western Australia (Perth, W. A., 1884 and 1885; with lists of fossils, rocks, and minerals, maps and plates).

[2] Palæozoic Fossils, vol. i. 1861–65, p. 17 (1861). Mr. Billings originally described three species, viz. *S. pulchella*, *S. rugosa*, and *S. obtusa*, but the last is, according to the excellent authority, C. D. Walcott, a species of *Hyolithes*.

upon this genus are those of C. D. Walcott,[1] who remarks that "the genera *Conularia*, *Hyolithellus*, *Coleoprion*, *Coleolus*, *Hemiceras*, *Salterella*, *Pterotheca*, *Phragmotheca*, *Matthevia*, and perhaps *Palæniyma*, form a group that, although representative, in a measure, of the recent *Pteropoda*, differ in other respects so much that it appears as though a division of the *Gasteropoda* equivalent to the *Pteropoda* might be consistently made to receive them." Walcott constitutes a Family—Salterellidæ—for the reception of *Salterella;* the rest of the families belonging to this Palæozoic group being Hyolithellidæ, Tentaculidæ, Conularidæ (Salterellidæ), Matthevidæ, and Pterothecidæ.

Describing the genus *Salterella*, Walcott remarks that "the shells of the species of this genus are strong and comparatively thick, much more like those of *Tentaculites* than *Serpulites*," and he adds, "I am inclined to agree with M. Barrande[2] that the relations of the genus are with *Tentaculites* and *Hyolites*"

The species of *Salterella* found in Canada are from the Middle Cambrian (Georgia Group, of Walcott[3]); the British species, *Salterella* (*Serpulites*) *Maccullochii*, Salter, is found in the Durness Limestone of Sutherlandshire, a somewhat higher horizon.

Locality.—Kimberley District.

CRUSTACEA.

PŒCILOPODA.

OLENELLUS ? FORRESTI (Etheridge, jun., sp., MS.), n.sp. Pl. IV. Figs. 2, 2*a*, 2*b*.

The specimen representing this species consists only of that part of the head which is contained within the free cheeks. The general outline of the head was probably semicircular and rather strongly convex; it was bordered by a narrow, rounded rim, only the front part of which is preserved, as seen in the figure. The glabella, which is somewhat damaged, is of an elongate conical form, widening gradually from the posterior to the anterior extremity; the front of it almost touching the marginal rim. Four pairs of glabella furrows are present, the front pair very faintly marked. The eyes are elongate, narrow, and extend in a broad arch from opposite the front or anterior glabellar lobe to the occipital furrow. The space between the eye-lobes and the glabella is slightly elevated. The occipital segment is apparently destitute of a spine.

On the weathered surface of a similar limestone rock, and from the same locality as the head just described, there is a short spine (Fig. 2*a*) probably belonging to the present species; if so, it would be the telson. In another piece of limestone similar to those containing the head and telson there is a portion of a thoracic segment (Fig. 2*b*), which agrees in form with the first two segments of an *Olenellus;* this may also belong to the present species.

[1] Second Contribution to the Studies on the Cambrian Faunas of North America, Bull. United States Geol. Surv. No. 30, 1886, pp. 131, 143.

[2] Syst. Sil. de la Bohême, 1867, vol. iii. p. 138.

[3] Second Contribution on the Cambrian Faunas of N. America, Bull. U.S. Geol. Surv. No. 30, 1886, pp. 20-24.

The conical form of the glabella of *O.*? *Forresti* would, at first sight, suggest its affinity with *Ptychoparia* (= Conocephalites[1]), but the shape and position of the eye-lobes contradicts any such conclusion. From *Olenellus* it differs too in its conical glabella, but as its characters appear on the whole to be nearer to that genus than to any other, I have placed it therein.

Locality.—"River south of base line;" Kimberley District.

II. DEVONIAN.

BRACHIOPODA.

SPIRIFERA? Plate V. Fig. 1.

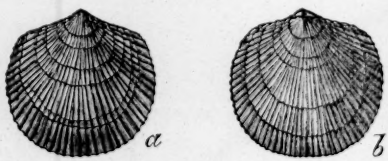
This specimen is too imperfect to warrant any conclusion as to its affinities. It is a fragment, apparently of a ventral valve, with a deep mesial sinus and prominent beak. The shell, which has lost the outer layer, is quite smooth and of a silky appearance; some fine radiating striæ are seen near the umbo.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District, in a coarse calcareous grit.[2]

ATRYPA RETICULARIS, Linnæus.

1864. *Atrypa reticularis*, Davidson, British Foss. Brach., vol. iii. part vi. p. 53, pl. x. figs. 3, 4.
1877. *Atrypa reticularis*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. ii. p. 97.
1877. *Spirigera reticularis*, M'Coy, in Rep. of Progress, Geol. Surv. of Victoria, p. 158.
1878. *Atrypa reticularis*, Etheridge, jun., Cat. Australian Fossils, p. 47.
1880. *Atrypa reticularis*, Etheridge, jun., Proceedings Royal Phys. Soc. Edinburgh, vol. v. p. 312, pl. vii. fig. 2.

This well-known and cosmopolitan species has already been found on the Australian Continent, at Yass and Kempsey, New South Wales, and Bindi, Victoria. Its discovery in the Kimberley District indicates the presence there also of rocks of Devonian age, as it is not known to occur above that horizon. The specimens, though



immature, exhibit all the external characters of this easily recognized form. One of them is figured in the accompanying Woodcut, in which *a* represents the ventral and *b* the dorsal aspect of the shell. At the same locality (Mount Pierre) there occur also two well-

[1] For the history of the generic names *Conocephalus*, *Conocoryphe*, *Ptychoparia* and *Conocephalites*, see Bull. United States Geol. Surv., No. 10, 1884; C. D. Walcott, "On the Cambrian Faunas of North America," p. 34. See also Dr. H. Woodward, on the same subject, in Quart. Journ. Geol. Soc. 1888, vol. xliv. p. 77, footnote.

[2] This fossil is in a precisely similar mineral condition to the other Brachiopods from the same locality.

known and widely distributed species of *Rhynchonella*, viz. *R. pugnus* (two varieties), and *R. cuboides*, both of which commence in the Devonian, and pass up into the Carboniferous. These species occur also at Rough Range, the significance of which fact will be recognized farther on. The other fossils included in the Devonian consist of species of *Spirifera*, *Orthoceras*, and *Goniatites*, all from Mount Pierre, and although they cannot be specifically determined, their occurrence in the same locality as the Rhynchonellæ, and in a similar matrix, warrants the conclusion that they belong to the same horizon.

Mr. Hardman notices the occurrence of Devonian fossils on the Margaret River, a tributary of the Fitzroy, in his second "Report on the Geology of the Kimberley District," 1885, p. 17, but he does not say to what species they belong. The following is the passage in his report to which I refer:—"The greater part of the limestone in this region is very fossiliferous. In several places in Rough Range, at Mt. Pierre, at Mt. Krauss, to the south of Hull Range, and in the rocks opposite to that hill on the south side of the Margaret, quantities of fossils of Carboniferous age were obtained, including Sponges (*Stromatopora*); Corals of several varieties; Annelids, Spirorbis, and Serpulæ; Polyzoa, Brachiopods; Lamellibranchs; Gasteropods, and Cephalopods. A few of these fossils are characteristic of the Devonian rocks, while others with which they are associated are as distinctly Carboniferous. This would denote, therefore, that these limestones belong to the Lower Carboniferous period, as it is not uncommon to find beds in the Lower Carboniferous, where fossils peculiar to both these formations intermingle to some slight extent; as, for instance, in the Lower Carboniferous rocks of Ireland, where in the county Cork true Devonian fossils are found along with the more characteristic Carboniferous fossils."

It would have been more satisfactory had Mr. Hardman given the names of the Devonian species which he alleges to have been found intermingled with Lower Carboniferous ones in the Kimberley District. This he has not done. But besides the evidence of the existence of Devonian rocks in this region supplied by such a characteristic species as *Atrypa reticularis*, there is that afforded by the Stromatoporoids from Rough Range, to be described in a forthcoming paper by Dr. H. Alleyne Nicholson, who finds that they are of Middle Devonian age.

RHYNCHONELLA PUGNUS, Martin, sp. Pl. V. Figs. 2, 2*a*.

1809. *Conchyl. Anomites*, Martin, Petrificata Derbiensia, pl. xxii. figs. 4, 5.
1864. *Rhynchonella pugnus*, Davidson, British Devonian Brach., pt. vi. p. 63, pl. xii. figs. 12–14, pl. xiii. figs. 8–10.
1876. *Rhynchonella pugnus*, ? de Koninck, Rech. sur des Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. i. p. 97.
1875. *Rhynchonella pugnus*, Etheridge, jun., Cat. Australian Fossils, p. 54.

Two variations of this species occur in the Collection. One (Fig. 2) resembles the tumid forms figured by Davidson in his British Carboniferous Brachiopoda (pl. xxii.), the other (Fig. 2*a*), the flatter and broader forms (var. *anisodonta*), figured on plate xii. fig. 12 of that author's British Devonian Brachiopoda.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District.

RHYNCHONELLA CUBOIDES, J. de C. Sowerby, sp. Pl. V. Fig. 3.

1840. *Atrypa cuboides*, J. de C. Sowerby, Trans. Geol. Soc. 2nd ser. vol. v. pt. iii. p. lvi. fig. 24.

1865. *Rhynchonella cuboides*, Davidson, British Devonian Brachiopoda, pt. vi. p. 65, pl. xiii. figs. 17–21.

This species is represented by a few very characteristic examples.

Locality.—Rough Range, opposite Hull Range, Kimberley District.

CEPHALOPODA.

ORTHOCERAS, sp. Pl. IV. Fig. 3.

The specimen presents a natural section on the weathered surface of a mass of limestone; it is a slowly tapering fragment of the septate portion of the shell $3\frac{1}{2}$ inches long. The septa are moderately concave, and from 2 to $2\frac{1}{2}$ lines distant from each other at the broader extremity of the specimen, where it has a diameter of 5 lines, the narrower end measuring only 1 line in diameter. Nothing of the siphuncle is seen.

It would not be possible to give any indication of the specific affinities of such an imperfect fragment.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District.

GONIATITES, sp. Plate V. Fig. 4.

Three or four broken fragments are contained in the Collection, in such a condition as to make it impossible to do more than hazard a conjecture as to their affinities. They appear to be of the type of *G. rotatorius*, de Koninck (Descrip. des Anim. Foss. de Belgique, 1844, p. 565, pl. li. figs. 1*a*, 1*b*), judging by their lenticular form, with almost closed umbilicus and close-set sutures, sharply bent forward near the periphery.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District.

GONIATITES, sp. Plate V. Fig. 5.

This specimen is seen only in a polished section. It is too obscure for specific identity.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District.

III. CARBONIFEROUS.

(Upper or Sandstone Series of E. T. Hardman.)[1]

PLANTÆ.

Plate IV. Figs. 4, 4*a*, 5, 6, 6*a*, 7, 7*a*, 8, 8*a*.

Mr. R. Kidston, F.R.S.E., F.G.S., who has kindly examined the plant-remains, sends the following brief notes upon them:—"The specimens are all very badly preserved, but the Collection contains fragments of *Lepidodendron* (Figs. 4, 4*a*), mostly reduced to the "*Knorria* condition"[2]; *Stigmaria* (Fig. 5), rachis of ferns (?), (Figs.

[1] "Report on the Geology of the Kimberley District," 1885, p. 25.

[2] Mr. Kidston rejects *Knorria*, and says that "the plants for which it was formed are merely imperfectly preserved examples of *Lepidodendron*, and perhaps also individuals of other genera." See Cat. Palæozoic Plants in Depart. of Geol. and Palæont., British Museum (Nat. Hist.), by R. Kidston, F.G.S., 1886, pp. 167, 174.

6, 6*a*), and *Cyperites*-like leaf-fragments (Figs. 7, 7*a*), with many examples of their separated basal extremities" (Figs. 8, 8*a*).

Mr. William Carruthers, F.R.S., had suggested to Dr. Woodward that these thick triangular basal extremities of leaves, which are very abundant on some pieces of shale, might *perhaps* be broken-up fragments of bracts of cones of *Lepidostrobi*.

Localities.—All the specimens are from Yarralla Hill, near the mouth of the May River (King Sound), with the exception of the fragments of fern-rachis, which were collected at Forrest Hill.

BRACHIOPODA.

Chonetes? sp. Plate V. Fig. 6.

The ventral valve of a young (?) individual, separated from the matrix, the external surface minutely pitted, the interior showing muscular impressions. A row of five or six perforations on each side of the beak indicate that there were spines along the hinge-line, though they are not preserved.

Locality.—"Opposite Mt. Krauss," King Leopold Ranges, near the Fitzroy River, Kimberley District.

Strophalosia Clarkei, Etheridge, sp. Pl. V. Figs. 7, 7*a*, 8.

1872. *Productus Clarkei*, Etheridge, Quart. Journ. Geol. Soc. vol. xxviii. p. 334, pl. xvii. figs. 2, 2*a*, 2*b*.
1877. *Productus Clarkei*, de Koninck, Fossiles Paléozoiques de la Nouvelles Galles-du Sud, pt. iii. p. 203, pl. x. fig. 5, pl. xi. fig. 3.
1878. *Productus Clarkei*, Etheridge, jun., Cat. Australian Foss. p. 51.
1880. *Strophalosia Clarkei*, Etheridge, jun., Proc. Roy. Phys. Soc. Edinburgh, vol. v. p. 280, pl. ix. figs. 18—21, pl. x. figs. 22—28, pl. xi. figs. 29—31, pl. xii. figs. 32, 33.

Several detached dorsal valves (Figs. 7, 7*a*) occur in the Collection, showing beautifully perfect interiors. These I have but little hesitation in identifying with the above species, which has been very amply figured and described by my friend Mr. R. Etheridge, jun., though from very poor material. In the same matrix and from the same locality there are some convex valves (Fig. 8), which may possibly be the ventrals of the present species; but the outer shell being entirely absent, I am unable to offer a decided opinion about these fossils. The inner layer of the shell remaining upon them has a silky appearance and is finely punctate.

Locality.—"South-east of Mt. Abbott," on the Fitzroy River, Kimberley District, in a yellowish ferruginous sandstone.

LAMELLIBRANCHIATA.

Aviculopecten tenuicollis, Dana, sp. Pl. V. Fig. 9.

1847. *Pecten tenuicollis*, Dana, Amer. Journ. Sci., second series, vol. iv. p. 160.
1854. *Pecten tenuicollis*, Dana, in Wilkes's Expl. Exped. 1838-42 (published 1849–1854), vol. x. Geology, p. 705, Atlas, pl. ix. fig. 7.
1878. *Aviculopecten tenuicollis*, R. Etheridge, jun., Cat. Australian Fossils, p. 67.
1889. *Aviculopecten tenuicollis*, R. Etheridge, jun., Proceed. Linnean Soc. New South Wales, 2nd series, vol. iv. pt. ii. p. 203.

"Suborbicular, 24–costate, costæ very slender, subacute, smooth. Sulci shallow, nearly flat at bottom, and having an intermediate smaller costa. Ears moderately large. Cardinal margin straight.

Length $1\frac{1}{8}$ inches; height $\frac{1}{2}$ ($1\frac{1}{4}$?) inches; distance of larger costæ at lower margin of valve, about $\frac{1}{2}$ line. Apical angle, ears excluded, slightly exceeding a right angle."

This description agrees so well with the specimen in Mr. Hardman's Collection that there is no doubt about its belonging to Dana's species. It must be remarked, however, that in his previous description of *A. tenuicollis*, Dana states that the costæ are about twenty-four. In the specimen before me they number about twenty-six. The shell is the convex valve, as was also Dana's. The latter was obtained at Harper's Hill, New South Wales, in a sandstone.

Locality.—Liverynga, Kimberley District, in a yellowish ferruginous sandstone.

GASTEROPODA.

Euomphalus ? ? Pl. IV. Fig. 9.

This specimen is far too much damaged by weathering to afford any certain indication of its affinities.

Locality.—"Opposite Mt. Krauss," King Leopold Ranges, Kimberley District.

Pleurotomaria ? ? Pl. IV. Figs. 10, 10*a*.

This fossil is in the same condition as the above; such of its characters as are preserved are well represented in the figure. It may belong to one of the subsections of *Pleurotomaria*.

Locality.—"Opposite Mt. Krauss," King Leopold Ranges, Kimberley District.

CEPHALOPODA.

GONIATITES.

Goniatites micromphalus, Morris, sp. Pl. V. Figs. 10, 10*a*.

1845. *Bellerophon micromphalus*, Morris, in Strzelecki's Physical Description of New South Wales and Van Diemen's Land, p. 288, pl. xviii. fig. 7.
1847. *Bellerophon micromphalus*, M'Coy, Ann. Mag. Nat. Hist. vol. xx. p. 308.
1849. *Bellerophon micromphalus*, Dana, Geology of Wilkes's Expl. Exped. p. 708, pl. x. fig. 6.
1877. *Goniatites micromphalus*, de Koninck, Recherches sur les Fossiles Paléozoiques de la Nouvelles-Galles du Sud (Australie), p. 339, pl. xxiv. fig. 5.
1878. *Goniatites micromphalus*, Etheridge, jun., Cat. Australian Fossils, p. 89.
1880. *Goniatites micromphalus*, Etheridge, jun., Proceed. Roy. Phys. Soc. Edinburgh, vol. v. p. 304.

This species is represented by two small and imperfect examples in a yellowish ferruginous sandstone. They are both casts, and show no trace of septation.

Locality.—Liverynga, Kimberley District.

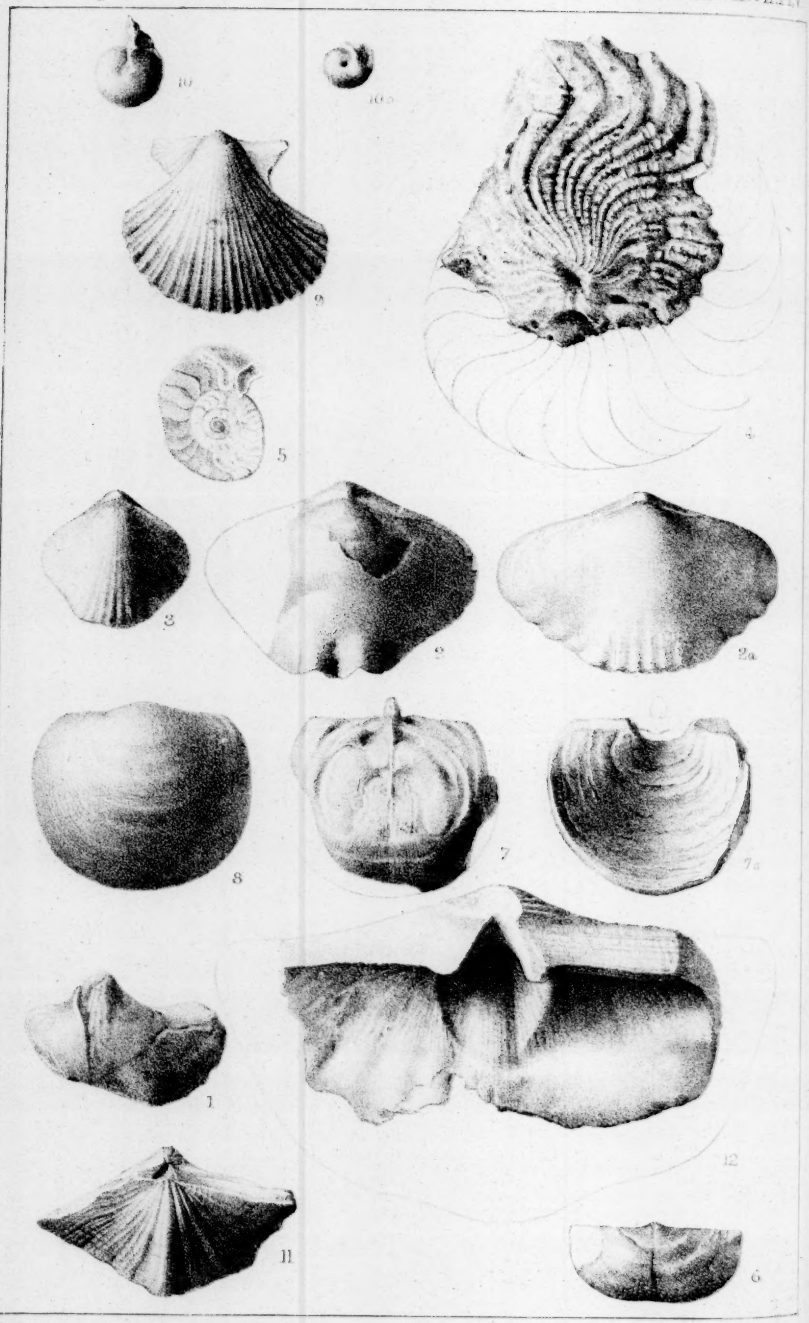
Carboniferous Fossils from the Gascoyne River and its Vicinity.[1]

ECHINODERMATA.

Plate IV. Fig. 11.

This group is represented by numerous weathered fragments of Crinoid stems, some loose, some imbedded in a limestone matrix. They have been examined by Mr. F. A. Bather, F.G.S., of the

[1] See "Notes on a Collection of Fossils and of Rock-specimens from West Australia, north of the Gascoyne River," by W. H. Hudleston, F.R.S., in the Quart. Journ. Geol. Soc. 1883, vol. xxxix. p. 582, where references to previous reports on the geology of this region may be found. The evidence afforded by the fossils of the



G. M. Woodward, del. et lith.

West, Newman imp.

West Australian Fossils.

Geological Department of the British Museum, and he believes them to belong probably to the *Rhodocrinidæ* or *Actinocrinidæ*, but he cannot refer them to any genus.

Locality.—Gascoyne River.

BRACHIOPODA.

SPIRIFERA KIMBERLEYENSIS, sp. nov. Plate V. Fig. 11.

The general outline of this species is transversely oval, with compressed valves and rather a long hinge-line. The ventral valve has a shallow median sinus occupied by three or four fine ribs, and bounded by two strong folds, which are most prominent in the umbonal region. About five more folds, made up of bundles of ribs, occur on each side of the last named, but they become almost obsolete in the depressed area near the hinge-line, on each side of the beaks. The beak is elevated, pointed, and but slightly incurved. The hinge-area is moderately deep, parallel, and as long as the width of the shell. The triangular fissure is tolerably large; no pseudo-deltidium is seen. The dorsal valve has a rather prominent median fold made up of five or six obscure ribs, and on each there are four or five less prominent folds, also made up of bundles of fine ribs, all of which tend to become obsolete in the flattened area near the cardinal angles. The whole of the surface of the shell is covered with very fine but distinct lines radiating from the beaks, and covering alike the folds and their interspaces; these lines can scarcely be seen without a lens. Fine concentric imbricating lamellæ are also present.

This species rather closely resembles *Spirifer Ambiensis*, Waagen ("Salt-Range" Fossils, Pal. Ind. ser. xiii. vol. i. 1887, p. 515, pl. xlviii. fig. 1), in the general character of its ornaments, especially in the bundles of finer ribs composing the folds of the shell, but the beaks in *S. Ambiensis* are more approximated than is the case in the present species, and furthermore, the fine radiating lines met with in the latter are absent in the former. *S. Kimberleyensis* is represented by a single specimen only, and it is most probably a young individual.

Locality.—Gascoyne River.

EXPLANATION OF PLATES.

PLATE IV.

FIG. 1. *Salterella Hardmani*; 1*a*, longitudinal section, 1*b*, transverse section, both enlarged.
" 2. *Olenellus? Forresti*, glabella; 2*a*, telson? 2*b*, thoracic segment.
" 3. *Orthoceras*, sp.
" 4. *Lepidodendron*; 4*a*, "*Knorria* condition" of same.
" 5. *Stigmaria*; surface of root showing areolæ.
" 6, 6*a*. Rachis of ferns (?).
" 7, 7*a*. *Cyperites*-like leaf-fragments.
" 8, 8*a*. Basal extremities of the same (or bracts of cone?).
" 9. *Euomphalus*? ?
" 10, 10*a*. *Pleurotomaria*? ?
" 11. Fragment of Crinoid stem.

Gascoyne River district (and those of a similar horizon from the Irwin River in the southern part of West Australia, and the Fitzroy River in the northern) is quite confirmatory of Mr Hudleston's views as to the age of the Australian Carboniferous, viz. that it corresponds with the Lower, rather than the Upper Carboniferous of other countries.

PLATE V.

FIG. 1. *Spirifera?*
,, 2, 2*a*. *Rhynchonella pugnus*, Martin, sp.
,, 3. *Rhynchonella cuboides*, J. de C. Sby., sp.
,, 4. *Goniatites*, sp. near to *G. rotatorius*, de Kon. ?
,, 5. *Goniatites*, sp. (section in limestone).
,, 6. *Chonetes?* sp.
,, 7, 7*a*. *Strophalosia Clarkei*; dorsal valves.
,, 8. *Strophalosia Clarkei?*, ventral valve.
,, 9. *Aviculopecten tenuicollis*, Dana, sp.
,, 10, 10*a*. *Goniatites micromphalus*, Morris, sp.
,, 11. *Spirifera Kimberleyensis*, sp. nov.
,, 12. *Spirifera Musakheylensis?* Davidson, var. *Australis*, var. nov.

[All the figures are of natural size, except where otherwise stated.]

(*To be continued in our next Number.*)

II.—Notes on the Culm-measures at Bude, North Cornwall.

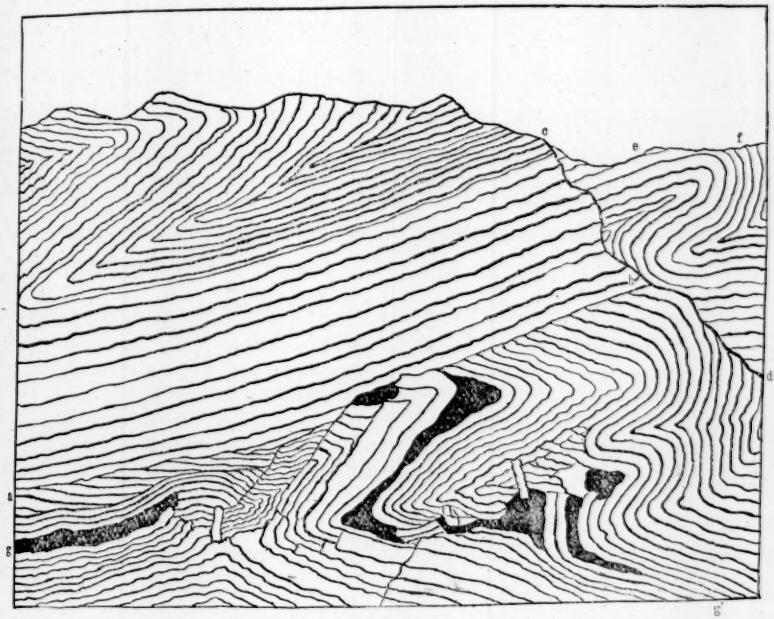
By Major-General C. A. McMahon, F.G.S.

DURING a residence of six weeks at Bude, in the autumn of 1889, I enjoyed the opportunity of studying the Culm-measures exposed in the bold cliffs of that part of the coast of Cornwall. I know of no easily accessible place where the flexures and contortions into which strata have been thrown by earth-movements can be studied with greater advantage. Between Bude-haven and Menachurch Point, a distance of one mile as the crow flies, there are at least eleven synclinal and as many anticlinal folds, presenting a variety of flexures of considerable interest to the geological student. At one place a sharp fold in the shape of the letter ∞ placed on its side, complicated by slight rupturing, has resulted in perpendicular beds being faulted in between strata dipping at a moderate angle in a common direction; whilst, at another place, a similar flexure has led to vertical strata being jammed in between beds dipping towards each other at a low angle. In some places the contortions and convolutions are too complicated for verbal description.

Menachurch Point itself presents several features of interest. The small headland that runs out from the cliffs and constitutes the "point" coincides with a small anticlinal flexure faulted along its apex. The smooth sides of the sharply-folded beds seem to have allowed the waves to slide over them without sustaining damage from the collision; whilst the fault itself, giving an advantage to the sea, enabled it to scoop out a deep cave at the very apex of the Point. The roof and walls of the cave are, for the most part, formed by one of the folded beds, and the fault caused by the rupturing of the strata along the axis of the fold is here seen at its minimum. As one mounts the ridge forming the headland, however, and rises to a level with the top of the cliffs, the throw of the fault gradually becomes greater, and the rupture between the beds on the two sides of the fold increases until, at last, one finds almost level strata faulted against nearly vertical beds. Unless one had traced the discordance between the two sides of the flexure step

by step, it would have been difficult to believe that so complicated a result had been produced in so simple a manner, and that less than a hundred yards, in point of distance, had been sufficient for its development.

The coast-line above described lies to the north of Bude. A similar state of things exists in the opposite direction. At the Haven itself the well-known feature called the "Whale's Back" is due to a sharp fold in the strata, and other contortions are to be seen in its immediate vicinity. The spot, however, likely to prove of most interest to the geologist is a little cove, three-quarters of a mile



Culm-measures, Efford Ditch, Bude, North Cornwall.

further south, called Efford Ditch. Here, high and bold cliffs are exposed which present for study a series of most complicated contortions and flexures. I spent many hours, on several occasions, attempting to draw these cliffs; but I found it impossible to give a general impression of the elaborate crumpling, faulting, and crushing, revealed by a close study of these rocks. Beds are not only doubled up and folded on themselves, but they are crushed, ruptured, and severed from each other in a way that has, in places, reduced them to the condition of a Chinese puzzle. In other places, again, where the arrangement of the beds looked tolerably simple, when viewed from a distance, a close inspection revealed some half-dozen small faults and sliding-planes, within as many yards. An extensive series of photographs would be required to convey to the mind of a person who had not studied the rocks themselves

anything like an adequate impression of the severity and extent of the contortion they have undergone.

In the accompanying illustration I have attempted to give a general idea of one of the least complicated sections. Imperfect though my sketch undoubtedly is, it will, I trust, suffice to show that the rocks have sustained a pretty good squeeze. The black portion (*g g'*) represents a bed of dark carboniferous shale; (*a*, *b*) is evidently a fault or sliding-plane, the beds below (*a*, *b*) being crumpled in the manner represented in the sketch; (*c*, *d*) represents the jutting edge of the cliff, the portion (*e*, *f*) stands back from it at some distance, and the connection between the convolutions of the strata at (*e*, *f*) and the beds between (*a*, *c*, *d*) cannot be seen from the point of view from which the sketch was taken.

A few miles further to the south, at Millhook, there is another interesting cliff, known locally as the Zigzag rock. Here the rocks were first compressed into an elaborate series of sharp V-shaped flexures, and then canted over *en masse* into a vertical position, so as to favour the impression that the squeeze came from above. A photograph of those rocks has been published in the Frith Series (No. 13144). It is an interesting photograph, but the stratigraphical details are not brought out with the clearness desirable for geological study.

As the Culm-measures at Bude have incontestably suffered from intense mechanical compression, I carefully collected good samples of these rocks in the field, and brought them back with me to London for study under the microscope. I was anxious to see whether they threw any light on the problem of dynamic metamorphism, and I was therefore especially careful not only to collect samples from all the principal varieties of rocks, but to take my specimens from places where the rocks had suffered most strain. For instance, if a bed had been doubled up on itself, I took my specimen from the knee of the bend; or if the fold had resulted in the snapping of the bed, from the point of rupture, where the strain had presumably been greatest. Of the darkest and most carbonaceous beds I was unable to obtain specimens, as they have been, under the influence of pressure, smashed up into a wafery dust, possessing no cohesion. A reference to the illustration will show how these beds are squeezed thin in some places; are pinched off in others; and swell out to bulky masses in yet other places. Here, at least, if nowhere else, I hoped to find the long-sought evidence of the molecular activity and of the chemical and mineralogical changes induced by great pressure. All that I found, however, was a dust of wafers, in which you might search in vain for a fragment as thick or as large as a sixpence. Pressure had failed to produce even consolidation or induration.

Since my return to London, I have examined under the microscope thin slices taken from the hand-specimens of the other beds, and I now proceed to state the results.

Macroscopically considered, these specimens are very fine-grained rocks, and vary in colour from a pale yellowish grey through pale

bluish grey to the dark colour of ordinary clay-slates. Some are distinctly arenaceous, and may be called fine-grained earthy sandstones; but they pass gradually into argillaceous shales of a slaty type. No cleavage is apparent, but some of the specimens are very distinctly laminated, and one exhibits traces of false bedding. In most of them very minute specks of silvery mica may be observed on the newly-fractured surfaces. Under the microscope these specimens are seen to be made up of quartz, felspar, and silvery mica, with occasional fragments of schorl, a few zircons, more or less decomposed felspathic or kaolinic material, magnetite, ferrite and carbon. Some slices contain calcite, and some magnesite, disseminated throughout them. There are also veins stopped with calcite. The calcite and magnesite, never exhibit twinning. It is evidently a secondary product of aqueous infiltration, and is not an original clastic component of the rock. Fragments of limestone rocks are entirely absent.

I now pass on to offer a few remarks on the principal minerals found in my specimens.

Carbon.—The dark lines of lamination which form a marked feature in some of the beds and simulate the fine banding of some crystalline schists, is mainly due to the deposition of carbon, and, in a very subordinate degree, to the presence of magnetite. The presence of carbon was verified in several ways; by the antimonate of potassa and nitric acid test; by the application of heat; and by digestion in hydrochloric and fluoric acids. Prolonged boiling in hydrochloric and in sulphuric acids failed altogether to remove the dark lines from thin slices, but the application of red heat over the Bunsen burner (applied in some cases before, and in others after, digestion in acids) effectually removed these dark bands.

The presence of carbon appears to be due to the deposit of vegetable matter along with very fine silt. Some of the specimens have obscure markings suggestive of vegetable matter, and one has a small fragment (the rest was broken off in the fracture of the hand-specimen) of what appears to have been the stem of a plant.

Though the dark lines and bands appear straight to the naked eye, they are seen, under the microscope, to owe their dark appearance to discontinuous fibres, and particles, of carbonaceous material distributed in the most irregular and uneven manner among the other materials. The carbon is not confined to the dark layers, but is distributed, though more sparsely, throughout the shales in which it occurs. In some it is very generally disseminated throughout the mass, and the rock has a uniformly dark appearance. Though the carbon for the most part is in threads, or fibres, it is perfectly opaque, and does not reveal under the microscope any trace of organic structure.

Iron.—Iron is present in the form of magnetite, ferric oxide, and apparently in combination with carbon. None of the hand-specimens attract the magnet, but splinters after fusion became magnetic. The iron was evidently deposited along with the carbon. Like the carbon, it is scattered promiscuously through the rock, but is more abundant in the dark carbonaceous bands than elsewhere.

Quartz.—Quartz is the most abundant material. It is in sub-angular to angular grains; these grains are rarely rounded and are never water-worn. They vary greatly in size in the same slice, ranging in the coarser-grained beds from one sixty-sixth to one eight-hundredth of an inch in their longer diameters. The orientation of such of the grains as are longer in one direction than in other directions is related in two slices only to the direction of the lamination; but in these two slices comparatively few of the grains are elongated and they are splintery fragments whose shapes are not due to pressure *in situ*. With these exceptions the grains of quartz, in the slices examined, are oriented in all directions. The silt, of which the rocks are made up, was evidently deposited in still water, and no secondary structure has been imposed upon these rocks since their consolidation.

Very few grains exhibit strain shadows, and as the grains that do so are exceptionally few in number, this structure was, it may be presumed, set up in them before they were deposited in the Culm beds. The elongated grains do not exhibit this structure.

Liquid, and other inclusions, in the quartz, where they take the form of lines, are not oriented in any common direction; each grain has its own system, which is not related in any way to that of its neighbours.

Liquid cavities with bubbles are a common feature in the quartz grains.

Felspar.—Occasionally, but rarely, the grains of felspar contained in the slices exhibit the polysynthetic twinning of the triclinic system. In the majority of cases the felspar is much decomposed and kaolinized.

Mica.—A silvery mica is present in all the slices, and is fairly abundant in most of them. As the important question to be determined, with reference to this mineral, is whether it is an original constituent of the rock, or a secondary product formed after the Culm beds were deposited, I have been at considerable pains to try and ascertain its species. Unfortunately the mica occurs in leaves of such microscopic minuteness that it is extremely difficult to isolate any of it, and impossible, I think, to obtain a sufficient quantity for a quantitative chemical analysis.

The mica is untouched by boiling hydrochloric or sulphuric acids; and after subjecting a portion of one of my specimens, reduced to fine powder in an agate mortar, to prolonged digestion in these acids, which apparently removed everything but the quartz, mica, and carbon, I tested the residue for potash and soda and found both these alkalies present. As this experiment was vitiated by the possibility that though I could discover no felspar under the microscope in the residue left by the acids, felspathic material might nevertheless have been left behind, I set to work again, and eventually succeeded in isolating a few very minute leaves of mica. Having previously tested these leaves under the microscope, to make sure that I had got hold of the real thing, I dissolved them in hot hydrofluoric acid, and tested, by microchemical processes, with

bichloride of platinum and acetate of uranium, and again obtained unmistakable evidence of the presence of both potash and soda. I also found some lime and magnesia. Iron was absent.

These results show, I think, that the mica must either be muscovite, paragonite (classed by Tschermak as a variety of muscovite),[1] or margarodite; but in the absence of a quantitative analysis, the chemical evidence does not enable us to say positively which of these it is. Margarodite may, however, be eliminated from consideration, as, according to Brush, this mineral is decomposed by sulphuric acid, whereas the mica of the rocks under consideration certainly is not. There remain muscovite and paragonite: both contain potash and soda, though in different relative proportions; but whilst muscovite contains up to 2 per cent. of magnesia and 0·5 of lime, these substances, though occasionally present in small quantities, are usually absent from paragonite.

But though the chemical evidence does not lead to any very definite result, the microscopic evidence gives a clear answer to the question raised. The mica presents the appearance of having settled down with the sand and mud when these beds were originally deposited. It is not arranged in continuous straight lines, or in planes in which mica is abnormally developed, but is scattered promiscuously throughout the rock. In many slices it is oriented in all directions, and even in those which exhibit a laminated structure, the leaves of mica are frequently oriented at variable and considerable angles to the lamination. The leaves of mica are often bent and occasionally ruptured, just as mica would be bent and ruptured if it were deposited in water along with grains of sand, and subsequently compacted by mechanical pressure between angular and subangular grains of such hard minerals as quartz and felspar. In this respect the Bude beds have a very close resemblance to the Tertiary Sivaliks of the outer Himalayas. In these mica was deposited along with grains of quartz, felspar, slate, and limestone, and the rocks being of comparatively coarse grain, the way in which the leaves were, in the process of consolidation, bent, crumpled, and ruptured, between the grains of quartz, felspar, etc., form an interesting study.

Schorl and zircon.—The schorl is generally in irregular-shaped grains such as one meets with in granites, but I have observed needles in some quartz grains that may be this mineral. The zircon is in regular crystals such as commonly occur in crystalline rocks.

Secondary minerals.—Exclusive of vein material, alluded to below, the only secondary substances I have observed are magnetite, ferric oxide, opalescent quartz, carbonate of lime, and magnesite; both of which latter are in a granular condition.

Veins.—Old cracks in the rocks are stopped in some cases with quartz, and in other cases with carbonate of lime. One slice contains three cracks, which present some features of interest. The one first formed in point of time is a thin one stopped with crystalline quartz. This was subsequently cut across by a wider crack,

[1] Third Appendix to Fifth Edition of Dana's Mineralogy, p. 77.

also filled with crystalline quartz, which is traversed by a third crack—the youngest in order of birth—stopped with carbonate of lime. The quartz in these cracks is full of liquid cavities with moving bubbles, but these inclusions do not orient in lines having a common direction. The feature to which I desire to call especial attention is that the second vein, in order of birth, has its quartz split up into narrow ribbon-shaped crystals, approximately at right angles to the direction of its length, but the older vein is totally devoid of this structure, and the carbonate of lime that stops the youngest vein exhibits no twinning. The twinning of calcite is commonly held to be the result of pressure, and I think the division of the second vein throughout its length into stripy quartz crystals, narrow as compared with their length, must be due to strain. We have then three cracks formed and filled with crystalline materials at different periods. No. 2 cuts the first formed at an average angle of 35°, and the last formed vein cuts No. 2 at an angle of 16°. The mineral stopping No. 2 exhibits evidence of strain, whilst the minerals stopping Nos. 1 and 3 are devoid of any such evidence. These facts seem to me to indicate that the strain which has left its marks on No. 2 could not have been applied subsequent to the crystallization of the mineral contents of all three veins, for had it been, there seems no reason why Nos. 1 and 3 should not have exhibited the marks of strain as well as No. 2. The facts seem to lead naturally to the inference that the strain which has left its marks on No. 2 was applied at a critical stage in its history when the quartz was in a condition to yield to that strain; and as this strain was applied after the quartz in No. 1 had passed that critical stage, and had hardened into its present condition, it was unaffected by it.

The evidence afforded by these veins teaches us that we should hesitate before we accept the evidence of strain exhibited by individual minerals, or groups of minerals, as proof that this strain was applied after the consolidation of the whole rock. This is an important point which is sometimes lost sight of.

Conclusion.—The Culm series, as seen at Bude, appear to have been deposited in tranquil water undisturbed by strong currents. Though there is occasional evidence of current, this is exceptional; and the materials of which the rocks are built up seem, on the whole, to have settled down quietly without much sorting, and without the longer axes of the grains being arranged in a common direction, which would have been the case had there been a sensible current. The layers of carbonaceous matter of organic origin point to the same conclusion.

Mr. Medlicott, in his Memoir on the Sub-Himalayan Rocks of N.W. India,[1] quotes the following remarks of a colleague, Dr. Kane, on the fossil leaves from the Tertiary rocks of the Sabathu group collected by the author of the memoir:—"A number of well-preserved plant-remains were found in the rocks of the Kasauli range. They are probably of Middle Tertiary age, and are

[1] Memoirs G.S.I. vol. iii. p. 97.

imbedded in an indurated shaly clay, bluish and slightly micaceous. It is evident from the regularity with which these remains are disposed—the leaves being in no case crumpled, or distorted, as well as from the fine texture of the rock in which they occur—that they have been deposited from water either perfectly still, or only slightly in motion."

I have several good samples of the Sub-Himalayan leaf-beds above alluded to, and have studied slices of them under the microscope. In point of *structure*, and in the character and arrangement of their component grains, and leaves of mica, they are indistinguishable from many of the Bude beds. If the one is composed of original materials deposited in still water, this statement must be equally true of the other.

This conclusion regarding the Bude rocks arrived at on purely microscopical evidence appears to agree well with the state of things described by Mr. A. J. Jukes-Browne, F.G.S., in his Building of the British Isles. After quoting from Prof. Green an account of the process of sedimentation that probably went on during the deposition of the Millstone Grit and Coal-measures, which is too long to give here, he adds in a footnote: "It would be better described as an immense delta or fenland, including many large lagoons and wide channels, surrounded by swamps which were never much above the level of the sea."[1]

So much for their manner of deposition. As regards their *origin*, the microscopical evidence favours the view that the materials of which the Bude rocks are composed were derived from the waste of a crystalline area, for they are made up of fragments of quartz, felspar, and mica, with some schorl and zircon crystals—all characteristic of granitoid rocks—together with some crystalline fragments of more schistose character. It is also material to note that they do not contain a single grain of such rocks as slate, or limestone.

I see no reason to suppose that the materials were derived from older sedimentary rocks, or that they travelled any great distance before they found their present resting-place. The absence of water-worn granules and the want of variety in the assortment of minerals are opposed to both these suppositions. The sand of rivers fed by extended catchment areas, or that flow for long distances over several geological systems, is usually as rich in specimens as a well-stocked mineralogical museum.

The specific gravity of slate and limestone does not differ very greatly from that of quartz and felspar, as will be seen from the following table:—

Clay-State (B. Von Cotta) ...	Sp. G.	2·5	— 2·8
Limestone (*ib.*)	,,	2·6	— 2·8
Quartz (J. D. Dana)	,,	2·4	— 2·8
Felspar (*ib.*)		2·56	— 2·75

If then the catchment area that supplied the Culm-beds at Bude contained exposures of slate or limestone, I think it is as certain as anything of the kind can be, that the Bude beds would have con-

[1] The Building of the British Isles, p. 90, footnote.

tained fragments of such rocks. The sand of the existing Panjab rivers, and the Sivalik beds, the product of Panjab rivers in the Tertiary period, abound in fragments of slate and limestone.

As a rule, I presume, heavy minerals are carried down by the main stream of a river, and the lighter ones are floated off over its banks to flood the country on either side of it; but this explanation can hardly be applied to the Bude rocks, as it would fail to account for the absence of such rocks as slate and limestone, on the one hand, or the presence of such minerals as schorl (sp. g. 3—3·24) and zircon (sp. g. 4·4—4·7) on the other. If schorl and zircon could have been floated to Bude, why not hornblende and other minerals?

Mr. A. W. Stokes, F.C.S., F.I.C., was good enough to make an analysis of one of the Bude samples for me, which I give below as No. I. The specimen was a slaty-looking shale.

	I.	II.	III.
Silica	73·20	73·70	74·54
Alumina	11·20	14·44	14·86
Oxide of Iron	8·40	1·92	2·76
Lime	—	1·08	·29
Magnesia	1·44	trace	trace
Potash	trace	4·43	3·73
Soda, with traces of potash, sulphates, and carbon.	5·26	Soda 4·21	3·49
Phosphoric acid ...	trace	trace	—
Water	·50*	·61	·87
	100·00	100·39	100·54

* Obtained by heating to 120° C. for four hours.

I have for the purposes of comparison given under II. and III. the analyses of two British granites made by Mr. J. A. Phillips, quoted by Mr. J. J. Harris Teall in his British Petrography, pp. 311, 314. I have selected these two because they come close to the analyses of the Bude rock in the per-centage of silica. II. and III. contain only a trace of magnesia, but in other analyses of granites made by Mr. J. A. Phillips this constituent rises to nearly 2 per cent.

An examination of the above analysis of the Bude shale bears out, I think, the result of the microscopic investigation. It seems to me to support the view that the silt deposited by the Bude waters was made up of granitic materials supplemented on the spot by the products of organic life, carbon, and iron; the carbon being derived by organic processes from the air, and the iron from the water.

One more point remains for consideration. Beyond all question the Bude rocks have, since their consolidation, been subjected to great lateral pressure, contortion, and crushing. On the other hand, it is equally certain that they could not by any stretch of the imagination be called metamorphic, or metamorphosed, rocks. But if dynamic force is capable of producing the metamorphic changes claimed for it by the exponents of dynamic metamorphism, how is it that the Bude beds are not metamorphosed? This is, I think, a pertinent question directly raised by the Bude beds, and one that is worth some serious consideration.

In offering a few concluding remarks on this subject, I propose

to leave out of consideration cases in which shearing is the alleged cause of metamorphism. Shearing would open up a very wide branch of inquiry, and as the Bude rocks do not exhibit cleavage, or foliation, or mineralogical changes that could be attributed to shearing, it will simplify matters to eliminate this branch of dynamic metamorphism from the discussion.

There remains the question whether pressure, apart from shearing, is capable of setting up molecular activity of such a character that the chemical constituents of a rock rearrange themselves in the manner implied by the use of the term metamorphism?

In this connection I do not think I can do better than quote from the highly interesting opening address of the President of Section G at the last meeting of the British Association.[1] After alluding to the mobility of the atoms or molecules of solid bodies, and after giving an account of Spring's experiments, Mr. Anderson goes on to say: "The same movements and changes have taken place and are still going on in Nature's laboratory. During the countless ages with which geology deals, and under the enormous pressures of superincumbent masses, stratified sedimentary rocks become crystallized, and assume the appearance of rocks of igneous origin, and not only so, but rocks of whatever origin, crushed and ground to pieces by irresistible geological disturbances, reconstruct themselves into new forms by virtue of the still more irresistible and constant action of molecular forces and movements."

The student must not allow his mind to be mystified, or carried away from the real point at issue, by such phrases as "the countless ages with which geology deals." The Alps and the Himalayas had their birth in Tertiary times, and if the rampant metamorphism of Himalayan rocks is to be referred to the dynamic throes of mountain-making, those throes were, geologically speaking, of yesterday's date, and we cannot indent on "the countless ages with which geology deals" to impart a poetic and occult glamour to the prosaic details of dynamic force exerted so recently as the Middle Tertiary period.

One other remark I would make, and that is, that laboratory experiments, like Spring's, however instructive and valuable, hardly run on all fours with the conditions that exist in nature. Mr. Anderson, for instance, with his eye on Prof. Spring's pestle and mortar, speaks of rocks, like Spring's powders, being "crushed and ground to pieces by irresistible geological disturbances" before they began to "reconstruct themselves into new forms by the still more irresistible action of molecular forces and movements." I am not sure whether Mr. Anderson considers this grinding to powder an essential part of the process in every case; if he does not, Spring's experiments may be put out of court at once; if he does, this assumption, it seems to me, is likely to prove fatal to the theory. In the Himalayas we have to deal with outcrops of foliated granites, not to speak of other crystalline rocks, ten miles thick and hundreds of miles long, and can any one, I would ask, believe that these

[1] Nature, September 19th, 1889, p. 510.

beds were ground down to a powder before they were re-consolidated into crystalline schists? The crushing of rocks to powder must surely have been a local phenomenon very limited in its extent.

One hears much of Spring's experiments, but I have seen no reference to those of Hallock,[1] who subjected layers of antimony, beeswax, parafine, ground bismuth, a second layer of parafine and lead, with silver pieces stuck on the wax and parafine, to the pressure of 6000 atmospheres. The materials came out unchanged, unmelted and unmixed. The silver coins left their marks on the steel sides of the instrument employed, but they did not sink through the wax or parafine, which they would have done had the wax or parafine liquefied. Mr. Hallock drew the conclusion from his experiments that "to me they seem to establish that pressure alone cannot truly liquefy a solid, *i.e.* diminish its rigidity, consequently we should scarcely expect chemical or mineralogical changes to be produced by pressure alone."

In the Bude rock we have laid bare for our study, not a laboratory experiment made under artificial conditions, but the operations of Nature herself. The rocks are contorted, crushed, ruptured, and compressed; they have undoubtedly been subjected to very great pressure; how is it that they are not metamorphosed if pressure alone is competent to produce metamorphism? It cannot be said that they have not been subjected to enormous pressure. It cannot be said that they have not been sufficiently mellowed by the lapse of those "countless ages with which geology deals," for the disturbances that crumpled the Culm-measures would seem to have been of considerably greater antiquity than those that gave birth to the Himalayas. How are we to estimate the intensity of a squeeze except by the crushing and crumpling produced by the squeeze? To say that the rocks would have been metamorphosed had the squeeze been sufficient in intensity and duration is to beg the whole question.

That metamorphic rocks are often highly contorted rocks may be freely admitted, but it does not follow from this fact that pressure and metamorphism are related to each other as cause and effect. Indeed, though contortion and metamorphism are sometimes found to coexist in the same rocks, they are sometimes found apart. The Bude rocks show that highly contorted rocks are sometimes devoid of metamorphism, and I can point to the converse case where highly metamorphosed rocks are devoid of contortion. I can point to a considerable area in the N.W. Himalayas in which metamorphism is at its maximum, but where the beds give little or no evidence of disturbance.

In my first paper on Himalayan Geology I described my passage over the Rupin[2] and some other passes. The beds traversed were mica schists, siliceous schists, and gneiss. For a distance of 40 miles, measured in straight lines on the map, and up and down over strata exceeding 10,000 feet in thickness, the ever-recurring

[1] American Journal of Science, 1887, p. 277.

[2] Elevation 15,480 feet.

entry is "dip low," "dip flat";[1] and it is only at the commencement of this traverse that I noted "some crushing and contortion near Nara"; and at its termination at Roru,[2] that the dip, which for the last few miles had been "very low N.E., suddenly rose to 50° beyond Mandári, and then became perpendicular." Other traverses in that neighbourhood might be quoted; they would extend the area without modifying the result.

If then we find extreme metamorphism in cases where there is no contortion, and great contortion where there is no metamorphism, are we not justified in seriously doubting whether pressure alone, without some other concurrent cause, can produce metamorphism?

III.—Notes on the Geology of South Bedfordshire.

By James Saunders.

THE District included under the term "South Bedfordshire" is that which lies between the escarpment of the Lower Greensand and the extreme southern limit of the county. Within this area the portion that has been most closely examined is that through which the Midland Railway passes, every excavation of which has been visited, in many cases frequently, both during the construction of the line, and also subsequently. A section drawn approximately north-west and south-east through the district in question would cover about fifteen miles of country, and the principal strata underlying it are as follows:—

Oxford Clay and Coralline Oolite, near Ampthill.
Lower Greensand, Flitwick.
Gault, near Harlington.
Chalk Marl, Chalton cutting.
Totternhoe Stone, ,, ,,
Lower Chalk, ,, ,,
Belemnitella plena zone (Lower Chalk) between Leagrave and Luton.
Melbourn Rock (Middle Chalk) ,, ,, ,,
Rhynchonella Cuvieri zone (Middle Chalk) ,, ,, ,,
Middle Chalk, in massive blocks. Cutting S.E. of Luton.
Chalk Rock (top bed of Middle Chalk). Between Luton and Chiltern Green.
Upper Chalk, with numerous flints. ,, ,, ,,

Taking these beds in the order in which they are mentioned, which, although it is that of the sequence of formation, is the reverse of that of superposition, it is proposed in the following notes to give a brief account of their leading features, and also of the fossils that have been found in them.

At Ampthill the excavations for the approaches to the tunnel expose the Oxford Clay and Coralline Oolite. When first opened, the lines of bedding could be distinctly seen, but subsequent weathering has obscured many interesting features. The cuttings exhibit a series of beds of clay, brown at the top, and containing many small crystals of selenite, whilst lower down the beds are dark blue, and with them are intercalated seams of hard grey limestone, from a foot to eighteen inches in thickness. The lower beds have fewer selenite crystals in them, but these are more regular in form and beautiful in appearance. One specimen obtained from the

[1] Records G.S.I. vol. x. p. 219.

[2] Elevation 5250.

tunnel measured six inches in its longest diameter. The most frequent fossils are *Ostrea*, *Belemnites*, and *Ammonites*. Occasionally the bones of Ichthyosauri and Plesiosauri are found, some of which must have been from animals of enormous size. My notes say that "a single vertebra of *Plesiosaurus* taken from the tunnel weighed ten pounds." This is from information obtained from the workmen during the progress of the works, when the line was being constructed.

Near the village of Flitwick are two cuttings in the Lower Greensand, besides several sand-pits in the immediate vicinity. In most of the sections, especially the one near the railway-station, the dip of the beds is well exhibited. They consist of yellow and nearly white sands, alternating with dark bands of ironstone. This series of beds extends across the county beyond Sandy in a north-easterly direction, and near Leighton Buzzard towards the south-west. At Silsoe, about four miles east from Flitwick, is an extensive pit, in which is exposed a hard compact dark brown sandstone. This furnishes a building material which has been used in the locality for a long period, and is apparently that from which the present Silsoe Church has been constructed. So extensive is the sand-pit that much of it has been turned into a plantation, in the shade of which, on the ancient facings of the stone, numerous mosses and ferns luxuriate.

The cutting south-east from Westoning passes through a bed of dark heavy clay, which is apparently Gault. It exposes a continuous band of coprolitic nodules, which averages about a foot in thickness. This layer passes through about one-third of the northern portion of the cutting, and is parallel with the general dip of the beds of the locality. The fossils obtained when the section was first examined were *Lamna*, *Belemnites*, *Terebratula*, and *Parasmilia*.

Near the village of Chalton, in the parish of Toddington, the hills forming the Lower Chalk escarpment are pierced by an extensive cutting more than a mile in length. In addition to the exposure of beds in this excavation, there are also some large lime-works near the north-east end, close by the railway, in which are sections on a higher level than those of the adjoining line. Until the present year (1889) these have been for several seasons in active operation, and a considerable section of chalk is exposed. Consequent upon the abandonment of the works, a considerable talus has accumulated at the base of the deepest rock-face, which obscures some portion of the section that was formerly visible. In other parts of the workings the vegetable soil has been taken off by the workmen, leaving exposed tabular masses of Totternhoe Stone, which have been weathered into moderately thin plates, presenting a most desirable condition for seeking the contained fossils. These are both characteristic and interesting, and a diligent search will soon be rewarded by at least several forms of Brachiopoda. At the end of this paper is a list of the fossils both from this locality, and the other principal sections. A few of the most noteworthy obtained from the adjoining cutting, deserve, however, a passing notice.

Mr. Jukes-Browne, F.G.S., who has been most indefatigable in naming the fossils, and otherwise assisting with his extensive knowledge of their distribution, has in correspondence with me made certain comments on some of the specimens submitted to him, which will probably be of general interest. In a letter dated January 30th, 1887, he says: "There are several interesting specimens, among them the Turrilite being especially so, as it belongs to a species which has only yet been found in the south of England, *Turrilites Mantelli*." In another letter received shortly before, occurs the following extract: "The larger specimen (Belemnite) from Chalton is, I consider, a new species, and I am particularly pleased to have seen your specimen, because all I have seen before from the Totternhoe Stone were smaller, so that I was not sure whether it was a new species, or the young of *Belemnitella plena*. The fact of yours being larger, and still retaining the character of being the same width from top to centre, confirms my notion of its being an undescribed species.[1] Of the Brachiopoda from this cutting some prevalent forms are *Terebratula semiglobosa* and *Rhynchonella Martini*."

The same bed has also furnished two interesting specimens of a rare Crustacean, *Palæga Carteri*, H. Woodward, one of which was from the lower portion of the Chalk Marl, where it is bluish-grey, and the other from the higher part, which is distinguished as the Totternhoe Stone. The latter specimen possesses the caudal appendages by which Dr. H. Woodward was enabled to determine the affinities of the species, and which that gentleman has described and figured in the GEOL. MAG. 1870. It was hoped that during the progress of the excavations now being made in this cutting for the widening of the Midland line, additional examples of this interesting species would be brought to light, but at present these hopes are unrealized.

The following sections were observed at Chalton, Aug. 25th, 1889.

North-east end of pit of the Lime Works.

Soil	1 foot.
Lower Chalk	about 20 feet

South-west end of pit of the Lime Works.

Totternhoe Stone, above which the soil had been removed	2 feet
Clayey Chalk	½ foot
Chalk Marl	14 feet

Section in the cutting a few rods further south, close to the bridge.

Earthy Clay	3 feet
Chalk	5 ,,
Totternhoe Stone	2 ,,
Chalk Marl	about 33 ,,
Total at this the deepest part of the cutting,	about 43 ,,

The Totternhoe Stone is a marked feature at the northern portion

[1] Under date Jan. 21, 1890, Mr. Jukes-Browne expresses the opinion that the *Belemnite* is probably that figured by Sowerby (Min. Conch. pl. 600) under the name of *Belemnites lanceolatus*.

of this cutting. It comes to the surface a little north of the bridge in the immediate vicinity of the lime-works, and passes downwards with a gentle slope till it disappears southward at the level of the line. In another section on the same horizon exposed on the London and North-Western Railway between Dunstable and Totternhoe Mr. Whitaker has distinguished two beds of this stone. At the present time, however, there is only one that is easily visible, standing out in relief from the softer beds, the other being obscured by the detritus resulting from the weathering of the section. The presence of this stone is somewhat of a grievance at the lime-works adjoining this cutting, as it is utterly useless for lime. From its arenaceous composition it crumbles into powder during the burning, when by accident any of it is allowed to pass into the kilns. In some extensive works further westward, just at the base of the Totternhoe Knoll, there is a fine section of the Grey Chalk which overlies the Totternhoe Stone, but during the present year the stone itself can only be seen in very small sections. A few years since it was well exposed in the deepest part of the works, when it presented a surface of three or four feet in thickness of a massive dark grey sandy limestone; at least that was the depth then exposed. It is probable that during the next season a considerable quantity of it will be excavated, as there are extensive orders on hand for the Totternhoe Stone, which is required both in the restoration of a mansion in Scotland belonging to the Marquis of Bute, and also for St. Albans Abbey. It need hardly be said that this stone has been largely used in the construction of the churches of this district, of which examples are furnished not only by St. Albans Abbey, but also by Dunstable and Luton Churches. In the latter, nearly the whole of the tower is built of alternate cubes of Totternhoe Stone, and chalk-flints set in mortar, in this way utilizing the materials that were most easily obtainable. This was a matter of great importance in times when the only means of overland transport was by bad roads, or mere tracks.

Reverting to the sections that are exposed by the excavations made for the Midland Railway, there occurs a short distance from Leagrave towards Luton, a long and rather shallow cutting which exposes a series of beds in the Middle Chalk. Close by the railway, about a mile from Leagrave, and one and a half from Luton, some lime-works have been opened, where an interesting section is exposed, which descends below the level of the deepest exposure in the adjoining cutting. In the Quarterly Journal of the Geological Society for May, 1886, Mr. Jukes-Browne gives a detailed account of the section in the lime-works, from which it appears that beneath four feet of soil and thin-bedded chalk, there are seven feet of Melbourne Rock, and five feet of Chalk and shaly marl composing the *Belemnitella plena* zone, resting on fifteen feet of blocky Lower Chalk. Owing to the cessation of operations at this place, only a small part of the lowest bed is now visible, but the whole of the details of the other portions of the section may still be easily distinguished. The fossils recently obtained from these

works are enumerated in the list at the end of this paper, the most abundant form being *Ostrea vesicularis*, var. *Baylei*.

On the side of Hart Hill overlooking Luton are some of those terraces or lynchets so characteristic of the Chalk Hills. Other examples exist between Luton and Dunstable, near Chalk Farm, also above the Old Bedford Road, near Stopsley; and again near Chalton on the Lower Chalk escarpment, of which a figure is given in the Memoirs of the Geol. Surv. vol. iv. pt. i. p. 366, also in the curious valley at the base of Ravensbury Castle, on the border of Beds and Herts. This hollow, in the very heart of the hills, has sides as sharply outlined as though excavated by human agency, and in its extent describes nearly a semicircle. Commencing on a south-eastern aspect, it continues in that direction for a short distance, then turns sharply towards the east, gradually curving in a northern direction, till it eventually opens on the general trend of the escarpment at the village of Hexton, where several springs take their rise.

Between Luton and Chiltern Green there are several interesting exposures of beds in the Middle and Upper Chalk, along the courses of the G.N.R. and Midland lines, the most extensive of which are those of the latter railway. The first excavation of any extent is about a mile south-east from Luton; it contains many flints, breaks up into massive blocks, and in the opinion of Mr. Jukes-Browne is to be classified as Middle Chalk. Proceeding in the same direction, the cutting opposite to Luton Hoo Park presents an excellent section of the Chalk Rock, which is usually regarded as the line of demarcation between the Upper and Middle Chalk. The beds exposed in this cutting are, in descending order,

	Feet.
Chalk with flints	6 to 8
Upper thin seam of Chalk Rock, about	$\frac{3}{4}$
Chalk, intermediate to two seams of Chalk Rock ...	6 to 8
Lower seam of Chalk Rock	3 or 4
Middle Chalk, with flints at top	10 to 12

The Chalk Rock is excessively hard, so that, although crowded with fossils, it is difficult to develope them satisfactorily. In some places it is so indurated that it rings almost like flint when struck with a hammer. It is not, however, uniformly compact, for in other places it is easily pulverized. The prevailing colour is grey, sometimes merging into a creamy white, and it contains many green-coated nodules. There are two beds often faulted lying approximately parallel to each other, at a short distance apart.

The Chalk Rock also occurs on the opposite side of the valley at Luton, under the London Road hill. It was customary, some 40 or 50 years ago, when lime-works were in operation at this place, for the workmen to drive headings with a rather steep incline into the hill, until the Chalk Rock was reached, when they could excavate considerable chambers beneath it, as it formed an excellent roof for their workings. These tunnels were sometimes driven twenty yards under the hill on the western side of the London Road, and indications of the works may still be distinguished.

The Chalk Rock in the cutting previously referred to is one of the richest stations for fossils in this district. The Brachiopods and Echinoderms are always well preserved, but the more delicate shells of the univalves have perished almost without exception, leaving excellent casts of their external ornamentation, and a spiral mould of their interior. The Cephalopoda have also experienced a similar decay, and when broken show the divisions of their chambers, sometimes exhibiting also a cast of the siphuncle. The general facies of the fossils indicates a closer affinity with those of the Middle and Lower Chalk, than with those of the Upper Chalk.

Overlying the Chalk Rock, and forming the upper portion of the adjacent hills on each side of the valley, occurs the Upper Chalk, with numerous flints. It is white, friable, rather soft, and traversed by many joints, by which it separates into blocks of various sizes. Flint is present both as nodules, and in thin seams. Occasionally there are thin layers of a grey clay somewhat resembling fullers' earth, which indicate the lines of bedding.

Overlying the Chalk in many places may be observed drift sands and gravels, and Boulder-clay. The drift is often exposed in digging in the Luton Valley, and is to be seen also in the Leagrave and Biscot pits. It contains many rolled fragments of *Belemnites*, and both *Gryphæa dilatata* and *incurva*. A fine specimen of the latter was obtained from the gravel at Hart Hill, Luton, the edges being well preserved, it having been but little exposed to attrition.

The fossils proper to the age in which the drift was deposited that have been found near Luton are the scapula of a deer from the ballast pit that formerly existed near the first mile-stone north of Luton, and the tibia of a deer from the excavation for a cellar at the bank of Messrs. Sharples & Co., which was found lying about ten feet from the surface.

At the gravel pit near Biscot, Mr. Latchmore found a fine antler of a deer about twenty-two inches in length, also the core of the horn of *Bos*.

The Boulder-clay exists as a surface deposit in many places round Luton, as, for example, London Road Hill, and the People's Park. Specimens of many of the typical boulders, both sandstone and pudding-stone, may be seen in the immediate neighbourhood of Luton.

In connection with the surface deposits of South Bedfordshire, the supposed discovery of gold at Pulloxhill deserves a brief notice. The following particulars have been furnished by Mr. C. Crouch, of Kitchin End near Pulloxhill, who has courteously placed them at my disposal. Under date November 28th, 1889, Mr. Crouch writes:—"The report of gold at Pulloxhill is due to a bed of sand which may be traced from Pulloxhill Church in a north-easterly direction to the Thrift Wood. This bed of sand contains an interesting agglomerate. A specimen of this was submitted last summer by Mr. Cameron to Mr. Rudler, of the Jermyn Street Museum. He writes as follows: 'The rock containing the brilliant gold-suggesting flashes is a highly micaceous sandstone, mainly consisting of crystal-

line quartz with abundant mica. Crushed in a mortar, and the powder examined under a microscope, the quartz is much iron-stained, giving the material a yellow-brownish tint, which conspires with the glistering bronze colour of the mica to suggest a gold-bearing material.' The history of the various attempts to find gold is confused; but about forty years ago I believe a quantity of the rock was dug and taken away to be tested, apparently without result. This, however, was not the first trial. A grass field, about 25 chains north-east from the Church, has long been called 'Gold Close,' and in or near the Thrift Wood, about a mile north-east from the Church, you may see 'Gold Copse' marked on the Ordnance Survey (Map)."

Curiously enough, whilst the above correspondence was proceeding between Mr. Crouch and myself, an old book was brought under my notice by Miss Higgins, of Luton. It is entitled "Geology and History of England," Dodsley, Pall Mall, no date (probably fifty years old). Under the heading Bedfordshire, p. 3, it says: "At Pulloxhill, near Ampthill, some years ago a gold mine was discovered, but it is now entirely neglected, the profit falling short of the expense of extracting the metal from the ore." As the book from which this extract is taken is simply a compilation, its authority is very doubtful, and it may fairly be assumed that the operations in search of gold have been referred to erroneously as though they had been successful in a limited degree.

Apparently in every instance the seekers have been deceived by the glitter of the iron-stained mica, and have never found any of the precious metal, at least in appreciable quantity.

Some idea of the thickness and average dip of the beds that underlie Luton may be obtained from the data furnished in sinking the artesian well at the Luton Waterworks, and from a solitary record that is left of the boring at the Old Brewery in Park Street, Luton. Through the courtesy of the engineer of the waterworks, the writer was enabled to see the material brought up from the workings. In boring the well, the various beds of the Middle and Lower Chalk were passed through until a depth of 224 feet was reached, when the Chalk Marl was touched, identical in colour and consistency with what one finds at Chalton cutting, close to the bridge, some four miles N.W.; say about 30 feet from the surface. This would give approximately a dip of about 45 feet per mile. The boring was continued over 90 feet through this bed without reaching its base, when the workings were stopped at a depth of 322½ feet from the surface. It was found that there was no increase in the water-supply after passing into this stratum.

The only record known to myself of the artesian well at the Old Brewery, Park Street, Luton, is on a large brick in the outer wall of the market-room of the Cock Inn just opposite the Old Brewery. This brick was made from the material brought up from the bottom of the boring, and bears the following inscription: "F. Burr, 465 feet, Jan. 1828." From its appearance the brick is made from Gault, but there is nothing to indicate from what depth that clay was obtained, except that the surface of the Gault must be just

below the bottom of the waterworks boring, say at 325 feet, so the brick must be made from clay 140 feet down in the Gault.

The pleasing duty now remains to acknowledge my deep indebtedness to Mr. Jukes-Browne for his unwearied kindness in naming the chalk fossils, and in other ways; also to Messrs. Whitaker and Newton, as well as other members of the Staff of the Geological Survey, for their valuable assistance and suggestions during the preparation of these notes.

Fossils from South Bedfordshire.

Species.	Upper Chalk.	Chalk Rock.	Middle Chalk.
Ventriculites mammilaris	x		
,, *impressus*	x	x	
,, *angustatus*	...	x	
,, *alcyonoides*	...	x	
Camerospongia, sp. nov.	...	x	
Verrucocœlia tubulata	...	x	
Plocoscyphia flexuosa	...	x	
,, sp. ?	...	x	
Parasmilia centralis ?	...	x	
Micraster cor-testudinarium	x	x	
,, *cor-anguinum*	x		
Holaster cor-avium	...	...	x
Ananchytes ovatus	x		
Galerites globulus	x		
,, *sub-rotundus*	...	...	x
,, *conicus*	x		
Discoidea Dixoni	...	...	x
Salenia granulosa	x		
Cidaris Merceyi	x	...	x
,, *hirudo* ?	x		
,, *sceptrifera*	...	...	x
Cyphosoma Königii	...	...	x
Serpula plana	x		
,, *granulata*	...	x	
Terebratulina gracilis	x		
Terebratula semiglobosa	x		
,, ,, var. *bulla*	...	x	
Rhynchonella plicatilis	x	x	
,, ,, var. *octoplicata*	x	x	
,, *Cuvieri*?	x	x	
Pecten Beaveri	x		
,, *quinquecostatus*	x		
Lima spinosa	x	x	x
,, *striata* ?	...	...	x
Spondylus latus	x		
Ostrea larva	x		
,, sp. ?	...	...	x
,, sp. nov. ?	x		
,, *vesicularis*	x		
,, ,, var. *Baylei*	...	...	x
,, *Normanniana*	x		
Exogyra haliotoidea	...	...	x
Inoceramus Brongniarti	...	x	x
,, sp. ?	x		
,, sp. ?	...	x	

Species.	Upper Chalk.	Chalk. Rock.	Middle Chalk.
Hippurites Mortoni	..	...	x
Cypricardia trapezoidalis	...	x	
Pleurotomaria perspectiva ?	...	x	
Turbo gemmatus	...	x	
Trochus (cast)	...	x	
,, sp. nov.	...	x	
Natica (cast)	...	...	x
Cinulia (cast)	...	x	
Helicoceras, sp. nov.	...	x	
Scaphites Geinitzia	...	x	
Ammonites prosperianus	...	x	
Nautilus lævigatus	...	x	
Belemnitella mucronata, var. *quadrata*	x		
Rhyncholites	x	...	x
Ptychodus mammilaris	x	x	
,, *latissimus*	x	...	x
,, sp. ?	...	x	
Enchodus halocyon	x		
Corax heterodon (from Harpenden, Herts) ...	x		
Lamna acuminata	x	...	x
Otodus appendiculatus	x		
,, sp.	...	x	

Fossils from the Chalk Rock between Luton and Chiltern Green, other than those mentioned above, in the Collection of Dr. Morison. See "Trans. Herts Nat. Hist. Soc. vol. v. Dec. 1889."

Ventriculites radiatus
,, *muricatus*
Camerospongia campanulata
Cephalites perforata
Coscinopora infundibuliformis
Plocoscyphia convoluta
Polyjerea, sp.
Guettardia deltata
,, *stellata*?
Placotrema cretaceum
Micraster breviporus
,, *cor-bovis*, var.
Holaster planus
,, *trecensis*
,, sp. nov.
Cyphosoma radiatum
Serpula plexus
Balanus, sp.
Rhynchonella Mantelli
Terebratula biplicata
,, *carnea*
Ostrea Normanniana?
Lima Hoperi
Inoceramus latus
,, *mytiloides*
Mytilus, sp. ?
Arca galliennia
,, sp.
Cardita tenuicosta?
,, sp.
Trochus Marcaisi
Avellana, sp.
Rostellaria (two undetermined sps.)
Turritella, sp.
Ammonites carianus?
Scaphites æqualis
Baculites, sp.
Ancyloceras, sp.
Heteroceras, sp.
Turrilites scheuchzerianus?
Corax falcatus (tooth)

Fossils from the Melbourn Rock (Middle Chalk) and Belemnitella plena zone (Lower Chalk) between Leagrave and Luton.

Melbourn Rock.

Ostrea vesicularis, var. *Baylei*. Abundant.

Belemnitella plena zone.

Rhynchonella Cuvieri.
,, *plicatilis*.
Lepas (Crustacean).
Ostrea vesicularis, var. *Baylei*.
Ptychodus decurrens.
Lamna gracilis.

Species.	Lower Chalk.		Totternhoe Stone.		Chalk Marl.	
	Chalton.	Other localities.	Chalton.	Totternhoe.	Chalton.	Basement Bed, Barton, and near Hexton.
Pollicipes glaber	x					
Flabellina, sp.?	...	x				
Ventriculites	x					
Trococyathus, sp.?	x					
,, *conulus*	...	...	...	...	...	x
,, *Harveyanus* ...	...	...	...	...	...	x
,, *angulatus*, sp.?...	...	...	...	...	...	x
Micrabacia coronula	..	...	...	...	...	x
Pseudodiadema Carteri ...	...	...	...	...	...	x
Cidaris Bowerbankii	..	x				
Serpula annulata	x	x				
Palæocorystes Stokesii	...	...	...	...	...	x
Palæga Carteri	...	...	x	...	x	
Rhynchonella Mantelliana	x	...	x	..	x	
,, *sulcata*	...	...	...	...	...	x
,, *grasiana*	x	...	x	...	x	
,, *Martini*	...	...	...	...	x	
,, *Cuvieri*	x	x				
Terebratula striata	...	...	...	...	x	
,, *semiglobosa* ...	...	...	x	...	x	
,, *biplicata*	...	...	...	...	x	x
,, ,, var. *obtusa*	...	...	...	...	...	x
Magas pumilus	x					
Lima echinata?	x					
,, *aspera*	...	...	...	...	x	
Spondylus gibbosus	...	...	...	...	...	x
Plicatula inflata	x	...	...	...	x	
,, *pectenoides*	...	...	x	...	x	
Pecten quinquecostatus ...	x	...	...	...	x	
,, *fissicosta*	..	...	x			
,, *Beaveri*	...	...	x			
,, *orbicularis*... ...	...	...	x	x		
Ostrea carinata, var. *frons*	...	...	...	...	...	x
Dentalium (cast)...	x	...	x			
,, *ellipticum*	...	...	...	...	...	x
Pleurotomaria (cast)	x					
Aporrhais subtuberculata ...	x					
Solarium ornatum	...	...	...	...	...	x
Turrilites Mantelli	x	...	x			
Ammonites varians	x					
,, *Coupei*	...	...	...	...	x	
,, *Studeri*	...	...	...	...	...	x
,, *rostratus*	...	...	...	...	...	x
Nautilus, sp.?	x					
,, *elegans*	...	x	x			
,, *clementinus* ...	...	...	...	...	...	x
Belemnites minimus	...	...	...	...	...	x
,, sp.? near *plena*	...	...	x			
Coprolites	x	x				
Casts of Ganoid Scales? ...	x					
Ptychodus decurrens	...	x				
,, *latissimus*	...	x				
Notidanus microdon	...	x				
Lamna, sp.?	x					

Species.	Lower Chalk.		Totternhoe Stone.		Chalk Marl.	
	Chalton.	Other localities.	Chalton.	Totternhoe.	Chalton.	Basement Bed, Barton, and near Hexton.
Odontaspis gracilis	...	x				
Oxyrhina macrorhiza? ...	...	...	...	...	...	x
Cimolichthys striatus? ...	...	x	...	x		
Otodus appendiculatus ...	..	x	x	...	...	x
Plesiosaurus, sp. ?	...	...	...	...	...	x
Ichthyosaurus campylodon ...	...	...	x			
,, sp. ?	...	...	...	...	...	x
Polyptychodon interruptus ...	...	...	...	...	..	x

Fossils from the Lower Greensand, Millbrook, Beds.

Sphærodus neocomensis.
Pycnodont, teeth (young).
Acrodus reticulatus.
Asteracanthus? dorsal spine, incomplete.
Ichthyosaurus, *Dakosaurus* ?, *Polyptychodon*, *Plesiosaurus* — teeth, some derived from the Oxford Clay.

An undescribed tooth, thought by Mr. E. T. Newton to be Reptilian.

Fossils from Ampthill, Beds.

Limestone Bands.

Cidaris florigemma, Phil.
Exogyra nana, Sby.
Pinna lanceolata, Sby.
Ostrea gregaria, Sby.
Trigonia irregularis ? Seebach.
Alaria trifida, Phil.

Oxford Clay.

Pentacrinus.
Cidaris Smithii, Wright.
Serpula tricarinata? Sby.
Rhynchonella varians, Schloth.
Gryphea dilatata.
Belemnites hastatus, Blain.
,, *sulcatus*, Mill.
Belemnites Owenii, Pratt.
Ammonites cordatus, Sby.
,, *plicatilis*, Sby.
,, *athletus*, Sby.
,, *biplex*, Sby.
,, near *Toucasianus*, d'Orb.
Ichthyosaurus.

REVIEWS.

I.—A Manual of Palæontology for the Use of Students, with a General Introduction on the Principles of Palæontology. By Henry Alleyne Nicholson, M.D., D.Sc., F.G.S., etc., Regius Professor of Natural History in the University of Aberdeen, and Richard Lydekker, B.A., F.G.S., etc. Third Edition. Re-written and greatly enlarged. In Two Vols. Royal 8vo. pp. 1624, with 1419 Woodcut Illustrations. (William Blackwood & Sons, Edinburgh and London, 1889.)

(*Continued from page* 87.)

IN a work undertaken by two or more authors, it is always difficult to secure uniformity of treatment; and a few striking differences are observable in the two volumes before us. As already remarked, while the microscopical characters of all the principal skeletal tissues

met with in each division of the Invertebrata are not merely described but well illustrated, not a single figure is devoted to the histology of the Vertebrata, and there are no descriptions of tissues that can be regarded as precise or in all respects accurate. Again, the excellent plan of printing in italics concise definitions of each of the great groups, adopted throughout the first volume, is not followed in the second; and the insertion among the figures of Vertebrata of several woodcuts, whose only interest consists in their antiquity, and of which the accuracy is in inverse proportion to their age, forms a striking contrast to the selection of figures employed for the illustration of the Invertebrata.

A brief general statement of the principal characters of the Vertebrate skeleton follows the definition of the sub-kingdom; and each class is subsequently treated in more detail at the head of the section relating to its extinct representatives.

In the general description of the Class Pisces, the absence of any precise description of the histology of the exoskeleton is especially unfortunate; and even more so is the allusion to Selachian dermal tubercles as "bony" and "supported on bone." One of the more frequent problems to be solved by the Palæichthyologist has reference to the true nature of detached fragments of the dermal armour of fishes; and the differences between (i) the vascular dentinal structure characteristic of Elasmobranchii and Chimæroidei, (ii) the isopedin of some of the earlier "Ganoids," and (iii) the true bone of Sturgeons and other "Ganoids," are so distinct and noteworthy, that the most elementary guide to the student ought to provide detailed descriptions with figures. The illustrations of cycloid and ctenoid scales (figs. 832, 833) will also prove somewhat confusing; the smooth posterior border being directed downwards in the first, and the prickly homologous border turned upwards in the second. The statement that there are no neural and hæmal arches in the vertebral column of Sharks (p. 915) is rightly contradicted by descriptions and figures in the following chapter; and the brief allusion to the "pelvis" on p. 919 is scarcely so explicit as desirable. The earliest known fishes are not Placodermata (as stated), but Pteraspidians; and, following the latest researches, the author dismisses conodonts with a brief mention, illustrated by the familiar figure. The classification proposed by Huxley, in 1876, is adopted, each of the six divisions being termed orders, and all except the first (Cyclostomi) having undoubted extinct representatives.

The Elasmobranchii are treated for the most part in accordance with the British Museum Catalogue; and the singular family of Squaloraiidæ is placed in the Chimæroidei on the authority of Dr. Traquair. The Dipnoi comprise the Lepidosirenidæ, Ceratodontidæ, Phaneropleuridæ, and Dipteridæ; and the Ganoidei follow, arranged and subdivided as suggested by Dr. Traquair. Here, unfortunately, some minor inaccuracies occur, and the selection of several of the woodcuts is far from satisfactory. The canals of the "lateral line," for instance, have only been found in the Pteraspidæ, not in the Cephalaspidæ; there are no Lower Devonian rocks in "North

Wales," *Holaspis* having been discovered in Monmouthshire; and *Didymaspis* is not Silurian, but Devonian. It is correctly stated that *Scaphaspis* has proved to be the ventral shield of *Pteraspis*; nevertheless, Lankester's erroneous figure with the mouth in the middle of the truly armoured abdominal region still survives. It would perplex any one but a specialist to comprehend the old figure of *Cyathaspis*; and the anal fin is even yet retained in the restoration of *Coccosteus*, notwithstanding M'Coy's assertion, thirty years ago, that such a feature did not exist in the numerous specimens he had examined, and that Agassiz's determination of its presence was doubtless founded on a mistake. It was excusable fifty years ago to make use of a Teleostean head to impart a life-like form to the dilapidated trunk of a Devonian Ganoid; but the progress of research ought, by this time, to have exterminated so fundamental an error. We are thus astonished to find Agassiz's restoration of *Dipterus* once more repeated (fig. 907), and, not only so, but now labelled *Thursius macrolepidotus*, through an unfortunate misunderstanding of recent researches. Huxley's restorations of Cœlacanths, with their broom-like dorsal fins, still persist, in spite of von Zittel's beautiful engraving of *Undina*; and a beginner might well be excused for failing to recognize a Sturgeon from the old caricature on p. 975. Most of the other figures of Ganoids, however, are satisfactorily up to date; the only serious inaccuracy occurring in Agassiz's restoration of *Aspidorhynchus*, where the rostrum, as well as the upper jaw, is shown to be provided with teeth.

In the arrangement of the Teleostei, Dr. Günther's classification is adopted; and the only important additions to the scheme occur in the section upon the Cretaceous forms. The provisional groups from the Chalk, distinguished by Smith Woodward, are named and regarded as families of Physostomi; and most of the genera are treated in accordance with the determinations of the same author. The enumeration of the extinct representatives of the later families will prove useful for reference, though somewhat uninteresting reading; and the majority of the illustrations are both artistic and accurate. The usual bibliography follows, with references to most of the principal works and memoirs; but we venture to suggest that the omission to record any of Egerton's contributions to the subject beyond a single brief technical note of limited interest, is scarcely doing justice to one of England's foremost palæontologists.

As may naturally be supposed, the chapter devoted to the Amphibia is chiefly concerned with a discussion of the Labyrinthodonts. These form an order, subdivided (after Anton Fritsch) into "four series or suborders, according to the external contour of the body and the nature of the vertebral column." The Bohemian *Branchiosaurus* is regarded as identical with the French *Protriton*; *Platyceps*, from the Australian Hawkesbury Beds, is said to be probably the same as *Bothriceps*, also Australian; and the South African genus, *Rhytidosteus*, is provisionally arranged with the Archegosauridæ. *Eosaurus* is degraded from its Reptilian rank held in the last edition of the work; and now rightly appears as a Labyrinthodont *incertæ*

sedis. Among later Amphibia, the family Hylæobatrachidæ is proposed for the Wealden Caudate genus *Hylæobatrachus* of Dollo; and the description of the Ecaudata is well up to date, though some reference might have been made, at least in the table of "Literature," to the recent elaborate researches of Wolterstorff.

In the Reptilia, the great groups are arranged chiefly according to the system proposed by George Baur. Four diverging "branches" are recognized, and it is remarked "that the close approximation to the Amphibia presented by the earlier members of several of these branches suggests the idea that Reptiles may have been derived from the Amphibians by more than one line of descent." The so-called order Proganosauria is thus rejected; and "the manifest affinity of [its type-genus] *Mesosaurus* to the more typical Sauropterygia, and of *Palæohatteria* to the Rhynchocephalia, seem to render it more advisable to refer those genera to the two orders in question, of which they will respectively form the most generalized stage."

The Theromorous Branch of Reptiles is regarded as comprising only a single order, that of Anomodontia, noteworthy for the resemblance of many of its features to those of the Labyrinthodont Amphibia, and of the Monotreme Mammalia. The order appears to be confined to the Permian and Trias, and is subdivided into Pariasauria, Theriodontia, Dicynodontia, and Procolophonia. *Pariasaurus* is noticed as described by Seeley; and *Anthodon*, also from the Karoo System, is included in the same family. The gigantic Anomodonts, *Tapinocephalus* and *Titanosuchus*, from the Karoo, form the first family of Theriodonts, and the pelvis named *Phocosaurus* is recorded as not impossibly referable to the former. The Placodontia are placed, as a group of uncertain rank and position, between the Theromorous and Synaptosaurian Branches; and the interesting fact is noted, that all known limb-bones from the Muschelkalk, in which the skulls of *Placodus* occur, are either Dinosaurian or Sauropterygian. The Synaptosaurian Branch comprises the orders of Sauropterygia and Chelonia, illustrated by numerous good figures; and the last-named order is further divided into the suborders of Athecata and Testudinata (Thecophora), in accordance with the researches of Cope, Boulenger, and Dollo. The opposite view of Baur is mentioned, but the Athecata are provisionally adopted as the more primitive (not degenerate) type; and "before a decisive opinion can be given on this question, it must be determined whether the absence of a bony connection in this group between the parietals and pterygoids is to be regarded as an acquired or as an original feature." The Streptostylic Branch comprises the orders Ichthyopterygia, Proterosauria, Rhynchocephalia, and Squamata, and the opening paragraph of the chapter relating to these is an interesting study in the complexity of taxonomy and nomenclature. All the Ichthyosauria are included in a single family; and in the Addenda (p. xi) the species *Ichthyosaurus platyodon* is made the type of a new genus, *Temnodontosaurus*. The Rhynchocephalia are divided into the suborders of Simædosauria, Sphenodontina, and Homæosauria, and *Palæohatteria* is placed first in a doubtful subordinal position.

Although the position of the mandible in Huxley's restoration of the head of *Hyperodapedon* is rightly stated to be erroneous, the figure is repeated without emendation; and, it may be added, materials are forthcoming for a much more accurate view of the skull of *Rhynchosaurus* than is given in the old woodcut, fig. 1038. With the exception of the Pythonomorpha, the groups of Squamata are not of much palæontological interest; but known facts are fully summarized, and the chapter ends with the portrait of a living Cobra. The Archosaurian Branch consists of the three orders, Dinosauria, Crocodilia, and Ornithosauria, which include the most highly developed and largest Reptiles, and make the nearest approach in their organization to the Avian type. The recently proposed subdivision of the Dinosauria into two orders is mentioned, but not adopted, and the so-called Stegosauria are merged with the suborder Ornithopoda. A restoration of *Megalosaurus* is copied from Mansel-Pleydell's Synopsis of the Dorset Fossil Reptiles; and the complex story of the British Atlantosauridæ is briefly related on p. 1175. The Aetosauria and Parasuchia are retained among the Crocodiles, and the Eusuchia form a third suborder, including Huxley's Mesosuchia, and divided into an amphicœlian and a procœlian series. In the account of the Ornithosauria the most important memoir of recent years (E. T. Newton, On *Scaphognathus Purdoni*, Phil. Trans. 1888) is singularly ignored; and we once more meet with woodcuts that are so well known to be erroneous that the impressions they give are even corrected in the text. It is time that such misleading and now exploded guesses at truth as those embodied in figs. 1095 and 1099 were consigned to the limbo of early palæontological failures. The omission to include the memoir of Newton just mentioned in the literature of the subject is also somewhat unfortunate; for this is accompanied by an appendix giving the most complete bibliography of Ornithosauria hitherto compiled.

The chapters on Aves are arranged chiefly in accordance with Prof. Alfred Newton's scheme of classification; and Dr. Gadow's latest researches on the Ratitæ are also mentioned. Many good illustrations are introduced, but a figure of the Berlin *Archæopteryx* would have been a desirable addition. Mr. E. T. Newton's well-known memoir on *Gastornis* ought also to have been noticed in the literature of the subject.

The general introduction to the Mammalia, which chiefly concerns the skeleton, is followed by an interesting sketch of the evolution of the class, so far as known. The classification adopted is that of Professors Flower and Huxley, and the latest discoveries all appear to be duly incorporated. The Mesozoic group of Multituberculata is provisionally placed among the Prototheria; while the numerous polyprotodont jaws of the same epoch are assigned to the Metatherian Marsupials. In the treatment of these early forms, Prof. H. F. Osborn's observations are largely quoted, and three of Professor Marsh's new figures are added. Among later Marsupials, the genera described by Sir Richard Owen from Australia are most conspicuous; but the upper incisors of *Diprotodon* in fig. 1155 are inaccurately

drawn, and the old erroneous theoretical restoration of the mandible of *Thylacoleo* is once more repeated, notwithstanding Sir Richard Owen's description of the actual fossil five or six years ago. In the Phalangeridæ, the premolar slopes outwards, not inwards as stated (p. 1286); and as regards *Bradypus didactylus* among the Sloths (p. 1300), we would remark that it is identical with *Cholœpus didactylus*, having two toes on the fore foot and three on the hind foot. A new figure of *Scelidotherium* by Prof. Capellini is added, from the Bologna Report of the International Geological Congress; and the extinct European genera, *Macrotherium* and *Ancylotherium*, are removed from the Edentates to the primitive Ungulates, adopting the recent determinations of Dr. Filhol. The name *Nothrotherium* is substituted for the pre-occupied *Cœlodon* (p. 1299): and the recent discovery of a Pangolin (*Palæomanis*) in the Isle of Samos is recorded. The Cetacea and Sirenia are fully treated, and the very long section on the Ungulata is profusely illustrated. The well-known evidences of evolution in the various types are pointed out, and several original observations are recorded. The resemblance between the skull of the newly-described *Samotherium* and that of the antelopoid genus, *Palæotragus*, is remarked upon; and the so-called *Macrotherium sivalense*, from the Siwalik formation, is placed in the Chalicotheriidæ, like its European representatives determined by Dr. Filhol. Prof. Marsh's new restoration of *Titanotherium* (or *Brontops*) *robustum* and Prof. Cope's figure of *Phenacodus primævus* are added; and the so-called *Dinoceras* and *Tinoceras*, from the Bridger Eocene of the United States, are described as identical with *Uintatherium*. For various reasons, however, Prof. Marsh does not adopt this earlier name, and the quotation on p. 1390, from that author, should have been precise. The enumeration of the extinct Rodentia is elaborate, though with few figures; and then follow the Carnivora, occupying thirty pages, illustrated by nearly forty woodcuts. Among the latter are valuable lateral views of the detached dentition of the Seal, Dog, and Bear; and the family Ursidæ, as in the author's previous publications, is defined as including both Dogs and Bears.

The last chapter is devoted to the Insectivora, Cheiroptera, and Primates; the former two orders being illustrated by figures chiefly of existing types, while some interesting figures recently published by Prof. Cope are incorporated in the account of the Lemuroid Primates. Nearly seventy works and memoirs are enumerated in the literature of the Mammalia, and we would add one more from which information has been obtained for the text, namely, Mr. E. T. Newton's Memoir on the Vertebrata of the Forest Bed.

The volume concludes with a section on Palæobotany, giving "an extremely brief and entirely general sketch of the past distribution and succession of the chief types of plant-life." This part of the work has been compiled by both the authors jointly, and numerous figures not given in the earlier editions are added. The bibliography is fully detailed, but Mr. Kidston's memoir on the Radstock Coal-plants, we observe, has been ascribed to another author.

In an appendix, several publications that have appeared during

the progress of the work are briefly noticed; and one of the footnotes is a protest against the making of such "uncouth" and "barbarous" names as *Wardichthys* and *Leedsichthys*. By some strange oversight, however, the most "barbarous" of all such names, *Gondwanosaurus* of Lydekker, is omitted from this category. The index of genera occupies about fifty pages, and almost every palæontological form of importance seems to be included.

II.—Contributions to the Micro-Palæontology of the Cambro-Silurian Rocks of Canada. Pt. II. pp. 27–57, with Two Lithographed Plates and Two Woodcuts. By E. O. Ulrich. (Geological and Natural History Survey of Canada. Montreal: W. F. Brown & Co., 1889.)

THIS is in continuation of Mr. A. H. Foord's previously published Report,[1] and the pagination and numbering of the plates of the two parts have therefore been made consecutive. The present Report (No. 4 of the series) is entitled "On some Polyzoa (Bryozoa) and Ostracoda from the Cambro-Silurian Rocks of Manitoba," and the author states in a brief introduction that his material consisted of a small collection of specimens made at various times between the years 1875–84, both inclusive, by different members of the Canadian Survey, but mostly by Mr. T. C. Weston.

The species of Polyzoa described include twenty from Stony Mountain,[2] five from St. Andrew's,[3] and one from Big Island, Lake Winnipeg. All the Stony Mountain species belong to the Hudson River Group, while of the St. Andrew's species two, *Monticulipora Wetherbyi*, Ulrich, and *Pachydictya acuta*, Hall, occur in the Birdseye and Black River Formation, and the other three (enumerated below) in the Trenton.

The following are the names of the Stony Mountain species:—

Proboscina auloporoides, Nicholson.
Proboscina frondosa, Nicholson.
Monticulipora parasitica, Ulrich, var. *plana*, n.var.
Homotrypa, sp. undescribed.
Batostoma Manitobense, n.sp.
**Petigopora scabiosa*, n.sp.
Batostomella gracilis, Nicholson (var.).
**Bythopora striata*, n.sp.
Bythopora? delicatula, Nicholson.
Monotrypella quadrata, Rominger.
Stictopora or *Rhinidictya*, sp. indt.
Dicranopora fragilis, Billings.
Dicranopora emacerata, Nicholson.
Goniotrypa bilateralis, n.gen. and sp.
Pachydictya hexagonalis, n.sp.
Ptilodictya Whiteavesi, n.sp.
Arthroclema angulare, Ulrich.
Helopora Harrisi, James.
Sceptropora facula, Ulrich.
Nematopora?, sp. undescribed.

The St. Andrew's species are:—*Monticulipora Wetherbyi*, Ulrich, *Fistulipora? laxata*, n.sp., **Pachydictya magnipora*, n.sp., *Pachydictya acuta*, Hall, and *Phylloporina Trentonensis*, Nicholson, sp. The species from Big Island, Lake Winnipeg, is named *Diplotrypa Westoni*, n.sp.

[1] Contributions to the Micro-Palæontology of the Cambro-Silurian Rocks of Canada, pp. 1–26, 7 plates and 1 woodcut, Ottawa, 1883.

[2] A hill some fifty feet in height, on the western bank of the Red River, not far from Winnipeg.

[3] A village and parish on the west bank of the Red River, about fifteen miles north-east of Winnipeg.

All the new species are figured, except the three distinguished by an asterisk; these probably were too thin or fragile to admit of the process of grinding into thin sections.

Under the description of *Diplotrypa Westoni*, Mr. Ulrich proposes a new family—*Diplotrypidæ*—to include (provisionally) the two genera *Diplotrypa* and *Monotrypa*, the author suggesting that it may be found necessary to break up each of these into two, but that further study and detailed comparisons are required before a final arrangement with regard to them can be effected. This he promises to bring about in a forthcoming work on Illinois Polyzoa.

The Ostracoda described in this report are, with one exception—*Eurychilina reticulata*—all from Stony Mountain, and consist of the following species:—

Bythocypris cylindrica, Hall, sp.
Leperditia subcylindrica, n.sp.
Aparchites minutissimus, Hall, sp.
Aparchites unicornis, Ulrich, n.var.
Primitia lativia, n.sp.
Primitia? (? *Beyrichia*) *parallela*, n.sp.
Eurychilina reticulata, n.gen. and sp., (from the Trenton shales of Minnesota.)
Eurychilina Manitobensis, n.sp.
Strepula quadrilirata, Hall and Whitfield, sp., var. *simplex*, n.var.
Strepula lunatifera, n.sp.

The author expresses his great obligations to Prof. T. Rupert Jones, F.R.S., for critical notes on these species.

The report concludes with a table prepared to show the stratigraphical range of those Manitoba species of Polyzoa and Ostracoda which have been found also in the United States, and from this we learn that out of 29 species from Stony Mountain, 20 are known to occur in the upper beds of the Hudson River or Cincinnati Group at localities in the United States.

The Canadian Survey is to be congratulated on having secured the services of so careful and experienced a worker as Mr. Ulrich for the difficult groups forming the subject of this report.

A. H. F.

III.—Descriptions of Eight New Species of Fossils from the Cambro-Silurian Rocks of Manitoba. By J. F. Whiteaves. From Trans. Royal Soc. Canada, Section iv. Nov. 1889, p. 75. Six Plates. (Montreal, Dawson Brothers.)

FOSSILS from such a distant region as Manitoba are valuable, not only as an index to the age and distribution of the rocks on the great continent of which that province forms a part, but also as attesting the interest taken in Geology by a people whose pursuits must leave them but little leisure for purely scientific studies. Nevertheless we find from Mr. Whiteaves' paper that some of the most notable of the fossils described by him were collected by members of the "Manitoba Historical and Scientific Society," and by that Society presented to the Museum of the Canadian Survey (Ottawa).

The species described, though numbering only eight, represent six genera, the first of which is a Gasteropod, and the rest Cephalopods, as follows:

Maclurea Manitobensis.
Poterioceras nobile.
,, *apertum.*
Oncoceras magnum.
Oncoceras gibbosum.
Cyrtoceras Manitobensis.
Trochoceras McCharlesi.
Apsidoceras insigne.

Maclurea Manitobensis is of very large size, attaining a maximum diameter of eight inches and a half. It is said to be more nearly related to the *M. Bigsbyi* of Hall, from the Trenton Group of Southern Wisconsin, and to the *M. cuneata* of R. P. Whitfield, from the Galena Limestone of the same State, than to either *M. magna*, Hall, or *M. Logani*, Salter.

To the genus *Poterioceras* two species are assigned—*P. nobile* and *P. apertum*; the first of these is referred provisionally to this genus "on account of its supposed simple and entire aperture," "but," adds the author, "it may prove to be a true *Gomphoceras*."

Mr. Whiteaves disagrees with Prof. Blake's view that *Oncoceras*, Hall, is synonymous with *Poterioceras*, M'Coy, and observes that the latter name "will probably have to be restricted to those straight, *Gomphoceras*-like shells in which the aperture is simple and entire"; in *Oncoceras*, on the other hand, "the shell is always distinctly curved and inflated in a peculiar manner in advance of the mid-length, while its body-chamber is transversely constricted just behind the aperture." It is thus seen that Mr. Whiteaves' contention in favour of the distinctness of *Poterioceras* and *Oncoceras* rests upon the assumption that the latter has a curved and inflated shell, and the former a straight, *Gomphoceras*-like shell. The constriction near the aperture can scarcely be reckoned as a distinctive generic character, because it is met with also in some species of *Orthoceras*. With regard to the inflation of the shell, that is a character common to both forms, as is admitted for *Poterioceras* in the expression "*Gomphoceras*-like"; and as to curvature, abundant proof exists that *Poterioceras* has a slightly but quite distinctly curved shell; this is seen in numerous specimens from the typical locality—Kildare, Ireland—whence M'Coy obtained the material upon which he constructed his genus. There therefore appears to be very little ground for separating *Poterioceras* from *Oncoceras*.

On looking at the figure of *Poterioceras nobile*, one is indeed struck with its *Gomphoceras*-like aspect, and the doubt expressed by the author as to whether it is really a *Poterioceras* will probably be shared in by most palæontologists who examine it in the light of the more recent researches in these fossils.

The uncertainty regarding the oral characters of such forms as these leaves room for considerable diversity of opinion as to the genus to which they belong, but our experience so far is opposed to their reference to the genus *Gomphoceras*, no fossil having yet been found below the Upper Silurian in which the complex, lobed aperture, characteristic of *Gomphoceras*, is preserved. This important structure being unfortunately absent in Mr. Whiteaves' specimens, the latter do not help us to settle the question of the range in time of *Gomphoceras*.

The species named *Cyrtoceras Manitobensis* is a very aberrant form of this genus, if indeed it really belongs to it, the presence of longitudinal to the entire exclusion of transverse ornaments being a feature hitherto unknown in other species of the genus. A. H. F.

IV.—Hampstead Hill: Its Structure, Materials, and Sculpturing. By J. Logan Lobley. With Chapters on the Natural History of the District by H. T. Wharton, F. A. Walker, and J. E. Harting. 8vo. pp. 100. With Nine Plates. (London, 1889.)

A USEFUL and readable companion to this interesting bit of country which is carefully described and well illustrated. After describing the geological structure of the Heath in detail, the author reprints a series of well-sections from Mr. Whitaker's "London Basin," gives a list of fossils which surprises by its fulness, and appends a useful bibliography, to which, however, may be added: John Bliss, Experiments and Observations on the Medicinal Waters of Hampstead and Kilburn. 4to. London, 1802, pp. 58,—a pamphlet which seems to have escaped bibliographers in general. There is also a mistake in the date of Goodwin's account of the Saline Waters; this interesting little book was published in 1804, the author apologizing for the delay in publication in his preface. Goodwin also adds a view of Pond Street in 1803 and gives a careful and accurate map of "Hampstead with some of the adjacent villages, and surrounding rides, 1803." Dr. H. T. Wharton contributes a list of the Plants, the Rev. F. A. Walker, one of the Insects, etc., and Mr. J. E. Harting writes on the Birds, giving notes of dates of appearance of the rarer visitors and accurate information as to their nesting places. Professor Lobley has wisely reproduced, by permission of the Council of the Geologists' Association, the late Mr. Caleb Evans' geological sketch map of Hampstead. C.D.S.

V.—Mount Vesuvius: A Descriptive Historical and Geological Account of the Volcano and its Surroundings. By J. Logan Lobley. 8vo. With Maps and Illustrations. (London, 1889.)

THIS new and revised edition of Professor Lobley's book fills up a gap in the literature of Vesuvius. The most recent memoirs on the subject have been laid under contribution, and the book is both readable and comprehensive.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 22, 1890.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communication was read:—

"On the Crystalline Schists and their Relation to the Mesozoic Rocks in the Lepontine Alps." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

In the debate upon the paper "On two Traverses of the Crystalline Rocks of the Alps" (read Dec. 5, 1888) it was stated that rocks had been asserted on good authority to exist in the Lepontine Alps, which contained Mesozoic fossils, together with garnets, staurolites, etc., and thus were undistinguishable from crystalline schists re-

garded by the author as belonging to the presumably Archæan *massifs* of that mountain-chain. In reply, the author stated that he regarded this as a challenge to demonstrate the soundness or unsoundness of the hypothesis to which he had committed himself. The present paper gives the result of his investigations, undertaken in the month of July, 1889, in company with Mr. James Eccles, F.G.S., to whom the author is deeply indebted for invaluable help. The paper deals with the following subjects:—

(1) *The Andermatt Section.*

By the geologists aforesaid, a highly crystalline white marble which occurs on the northern side of the Urserenthal trough, at and above Altkirch, near Andermatt, is referred to the Jurassic series (members of which undoubtedly occur at no great distance, almost on the same line of strike). The author describes the relation of the marble to an adjacent black schistose slate, and discusses the significance of some markings in the former which might readily be considered as organic, but to which he assigns a different origin. He shows that there are most serious difficulties in regarding these two rocks as members of the same series, and explains the apparent sequence as the result of a sharp and probably broken infold, as in the case of the admitted band of Carboniferous rock at Andermatt itself. That the section is a difficult one on any hypothesis the author admits; but after a discussion of the evidence, he concludes that "that tendered on the spot demands a verdict of 'not proven'—that obtainable in other parts of the Alps, will compel us to add, 'not provable.'"

(2) *The Schists of the Val Piora.*

These schists, already noticed by the author in his Presidential Address to the Society in 1886, occur in force near the Lago di Ritom, and consist of two groups:—the one, dark mica-schists, sometimes containing conspicuous black garnets, banded with quartzites, the other various calc-mica schists; between them, apparently not very persistent, occurs a schist containing rather large staurolites or kyanites. On the north side is a prolongation of the garnet-actinolite (Tremola-) schists of the St. Gothard, and then gneiss; on the south side gneiss. There is also some rauchwacké. This rock, at first sight, appears to underlie the Piora-schists, and thus to be the lowest member of a trough. If so, as it is admittedly about Triassic in age, the Piora-schists would be Mesozoic. The author shows that (1) the latter rocks do not form a simple fold; (2) they are beyond all question altered sediments; (3) they have often been greatly crushed subsequent to mineralization; (4) the garnets, staurolites, etc. (if not injured by subsequent crushing), are well developed and characteristic, and are authigenous minerals.

(3) *The Rauchwacké and its Relation to the Schist.*

(*a*) *The Val-Piora Sections.*—The author shows that the rauchwacké, which at first sight seems to underlie the dark mica-schist, is inconstant in position (on the assumption of a stratigraphical

sequence); that its crystalline condition does not resemble that of the schist-series, but is rather such as is common in a rock of its age; that it contains mica and other minerals of derivative origin, and in places rock-fragments which precisely resemble members of the Piora schist series.

(*b*) *The Val-Canaria Section.*—This section, described by Dr. Grubenmann, is discussed at length. It is shown that the idea of a simple trough is not tenable, for identical schists occur above and below the rauchwacké; that there is evidence of great pressure, which, however, acted subsequently to the mineralization of the schists; and that in one place the rauchwacké is full of fragments of the very schists which are supposed to overlie it.

(*c*) *Nufenen Pass, etc.*—Other cases, further to the west, are described, where confirmatory evidence is obtained as to great difference in age between the rauchwacké and the schists, and the antiquity of the latter. The apparent interstratification is explained by thrust-faulting.

(4) *The Jurassic Rocks, containing Fossils and Minerals.*

The author describes the sections on the Alp Vitgira, Scopi, and the Nufenen Pass. Here indubitable Belemnites and fragments of Crinoids occur in a dark, schistose, somewhat micaceous rock, which is often very full of "knots" and "prisms" of rather ill-defined external form, something like rounded garnets and ill-developed staurolites. These rocks at the Alp Vitgira appear to overlie, and in the field can be distinguished from the black-garnet schists. In one place the rock resembles a compressed breccia, and among the constituent fragments is a rock very like a crushed variety of the black-garnet mica-schist. These Jurassic "schists" are totally different from the last-named schists, to which they often present considerable superficial resemblance; for instance, their matrix is highly calcareous, the other rock mainly consisting of silicates. Some of the associated mica may be authigenous, but the author believes much of it and other small constituents to be derivative. There is, however, a mineral resembling a mica, exhibiting twinning with (?) simultaneous extinction, which is authigenous. The knots are merely matrix clotted together by some undefinable silicate, and under the microscope have no resemblance to the "black garnets." The prisms are much the same, but slightly better defined; they present no resemblance to the staurolites, but may be couseranite, or a mineral allied to dipyre. Hence, though there is rather more alteration in these rocks than is usual with members of the Mesozoic series, and an interesting group of minerals is produced, these so-called schists differ about as widely as possible from the crystalline schists of the Alps, and do not affect the arguments in favour of the antiquity of the latter. In short, they may be compared to rather poor forgeries of genuine antiques. Incidentally the author's observations indicate (as he has already noticed) that a cleavage foliation had been produced in some of the Alpine schists anterior to Triassic times.

Discussion.

Dr. Geikie having sent an abstract of the paper by Professor Bonney, read to the British Association at Newcastle, to Prof. Heim, the latter had favoured him with a résumé of his views on the subject, of which the following is a translation :—

"It appears to me that Professor Bonney starts from a misunderstanding. It has often been maintained that Mesozoic rocks can become crystalline; but *no* Swiss geologist has, so far as I know, *ever* asserted that the crystalline schists of the *Central massif* of the Alps are metamorphic Mesozoic rocks. In the printed abstract of his British Association paper, however, which you have sent to me, Professor Bonney attacks this supposed assertion—one that has never been made.

"I am in perfect accordance with those who know the *Central massif* best (Baltzer, Fellenberg, etc.) in fixing the following points:—

"1. Crystalline schistose rocks of Mesozoic age exist at Scopi, in the Valserthal (Graubünden), in the Userenthal, on Piora, at the Nufenerpass, in the Val Canaria, in the Ganterthal and numerous other places. Such rocks are:—

"(*a*) Clay-slates, with mica, garnets, zoisite, staurolite, rutile, and Belemnites, the latter being crystalline and granular.

"(*b*) Clay-slates, with mica, staurolite, etc., and garnet, alternating with the Belemnite-schists.

"(*c*) Green plagioclase-amphibole schists, alternating with the Belemnite-schists.

"(*d*) Micaceous phyllites and calcareous mica-schists.

"(*e*) Marble with mica, which has undergone linear stretching, going over into 'Malm-kalk' with crinoids.

"We have *never* given the name 'crystalline-schists' to these rocks, nor have we ever regarded them as such, but always as sedimentary metamorphosed zones (synclinal basins) *between* the central massifs. Professor Bonney is right in saying that they have not the aspect of true crystalline schists. It is true there are some varieties which it would be difficult to distinguish in the hand-specimen, and without stratigraphical evidence, from true crystalline schists. Stratigraphically, they always present themselves as 'Mulden-zones' accompanied by other sedimentary rocks.

"In the *Central massifs* occur rocks which exactly resemble true crystalline schists in mode of occurrence. Petrographically, they are related to them by passage-rocks; at least, the line of separation is not easily distinguished. Such rocks are *phyllites*, *chlorite-schists*, *felsite-schists*, *mica-schists*, and especially *sericite-gneisses*, all of which we regard with certainty as palæozoic. The proofs are the following:—

"(*a*) In some places in these zones are found intercalated beds of graphitic and sometimes even anthracitic schists (Brisenstock, etc.).

"(*b*) Traces of fossils have been often found (trunks of Calamites from Guttanen in the Haslithal, Carboniferous plants in strips wedged in on the Tödi, etc).

"(*c*) At the end of the Central-massif distinct zones of Carboniferous slates are often developed out of the zones of these sericitic gneisses; and the synclinal ('Mulden') nature of these zones, in comparison with the old granitic gneisses, is shown there by the wedging in of still younger unaltered sedimentary rocks.

"(*d*) I have already shown in my Tödi-Windgällen group that even the Verrocano (Permian), when nipped in between crystalline schists, assumes a close resemblance to them, and appears as a part of the crystalline Central-massif.

"Fragments of these rocks are found in the Triassic rauchwacké, but this is not the case with the garnetiferous schists of Scopi which are younger than the Rauchwacké, and belong to the true sedimentary synclinal zones ('Mulden').

"A great unconformity exists in the Central Alps between Palæozoic and Mesozoic formations, but not between Palæozoic and Azoic.

"I. The *Palæozoic* formations mostly show an intimate tectonic relation to the crystalline schists, and have been converted petrographically into crystalline schists. The *central-massifs* consist, perhaps to the extent of two-thirds, of true old crystalline schists, older than the Cambrian, in part, perhaps, the primitive crust (Erstarrungskruste, granite-gneisses, protogine); and to the extent of about one-third of Palæozoic mica-schists, sericite-schists, amphibolites and other similar rocks which have been derived by dynamic metamorphism from Palæozoic slates, sandstones, and

conglomerates; and Baltzer distinguishes between the old nucleus and the younger shell (slates) of the *Central-massif*. They are kneaded and pressed into one another.

"II. The genuine Mesozoic deposits follow, sometimes conformably, sometimes unconformably. In places they have become crystalline and schistose (*schiefrig krystallinisch*); but they never occur as a constituent of the *Central-massif*, but always accompany the Mesozoic deposits, or are intercalated as 'Mulden' in, and especially between, the *Central-massifs*. They are never termed 'Crystalline-schists' in the geological sense of the word, at the most only in its petrographical sense.

"The latest literature on these things is, above all:—

"*Baltzer*. 'The Aar-massif and a part of St. Gothard-massif.' 'Beiträge zur geol. Karte der Schweiz.' 24th Lieferung, 1888.

"*Grubenmann* (*Prof. Dr.*). 'The Sedimentary "Mulde" of Piora.'

"Baltzer furnishes in the volume above cited some excellent work on the above rocks indicated under I., and gives a drawing of the Calamite-like trunk from Guttanen. Grubenmann does the microscopic work in connection with the Mesozoic formations belonging to II., which have *never* been referred, by us, to the crystalline schists, or to the *Central-massif*.

"Result.

"Much of what have been regarded as genuine crystalline schists in the Alps is Palæozoic.

"The crystalline metamorphosed Mesozoic rocks always occur as sedimentary deposits, and have never been termed 'crystalline schists'" in the stratigraphical sense."

II.—Feb. 5, 1890.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Variolitic Rocks of Mont-Genèvre." By Granville A. J. Cole, Esq., F.G.S., and J. W. Gregory, Esq., F.G.S., F.Z.S.

The following conclusions were arrived at by the authors as the result of their observations:—

The gabbro or euphotide south of Mont-Genèvre is associated with serpentines, which were originally peridotites, and were not derived from the alteration of the gabbro. These coarsely crystalline rocks probably form a considerable subterranean mass, but have little importance at the surface.

They were broken through by dykes of dolerite and augite-andesite, and are now overlain by a great series of compact diabases and fragmental rocks, which has no direct connexion with the gabbro.

The variolite of the Durance occurs *in situ* as a selvage on the surfaces of contact of these diabases among themselves, as blocks in certain fragmental rocks, which are regarded by the authors as tuffs, and occasionally as a selvage to the diabase dykes.

This product of rapid cooling was originally a spherulitic tachylyte, and has become devitrified by slow secondary action. Variolite thus stands in the same relation to the basic lavas as pyromeride does to those of acid character.

The eruptive rocks in the Mont-Genèvre area are probably Post-Carboniferous, but their exact age cannot at present be determined.

There are several other areas of similar variolitic rocks among both the Alps and the Apennines of Piedmont and Liguria.

The best modern representatives of the conditions that produced these rocks are to be found in the great volcanoes of Hawaii, and there is nothing either in their fundamental characters or in their

mode of origin that cannot be paralleled among the products of causes now in action.

The authors expressed their indebtedness to Professors Bonney and Judd, as well as to those who have preceded them upon the classic ground of Mont-Genèvre.

2. "The Propylites of the Western Isles of Scotland, and their Relations to the Andesites and Diorites of the District." By Professor John W. Judd, F.R.S., F.G.S., etc.

The "Propylites" of von Richthofen and Zirkel constitute what has been aptly characterized by Rosenbusch as a "pathological variety" of the andesites. The relations of rocks of this type to the andesites and diorites in Eastern Europe and in the Western Territories of the United States have been made known to us by the researches of Dölter, Szabó, Becker, Hague and Iddings, and other petrographers.

The "felstones" described by the author of the present memoir as constituting the oldest series of the Tertiary volcanic rocks in the Western Isles of Scotland are now shown to belong to this interesting type. When found in an unaltered state, these rocks present remarkable analogies with the andesites of Iceland and the Faroe Islands, which have been so well described by Zirkel, Schirlitz, Osann, and Bréon. In the altered condition in which they usually occur, however, the Scottish rocks resemble in a not less striking manner the "propylites" of Eastern Europe and Western North-America.

The rocks in question vary in colour from white to dark grey, various shades of green usually prevailing among them. They have a specific gravity ranging from 2·4 to 2·9; the density diminishing as the silica percentage and the amount of glassy material in them increase; a lowering of the density of the rocks being also the result of extreme alteration. In their chemical composition these rocks were shown to agree with the pyroxene- and amphibole-andesites of other areas, and with propylitic forms of those rocks.

Very striking and remarkable is the amount of change that many of these Tertiary rocks have undergone—change that has equally affected their porphyritic constituents and the ground-mass in which these are imbedded. The felspars are never fresh, but are more or less kaolinized, and not unfrequently converted into epidotes and other secondary minerals; the ferro-magnesian silicates are almost always changed into isotropic "viridite," or into various chlorites; while the titano-ferrite and magnetite have been converted either into "leucoxene" or into sulphides. The glass and microlites of the original ground-mass have in nearly all cases disappeared as the result of secondary devitrification.

The propylites are the oldest of the Tertiary lavas in the Western Isles of Scotland. They exhibit every gradation in minute structure, from holocrystalline forms (diorites) through various "granophyric" and "pilotaxitic" types into true vitreous rocks ("pitchstones"). They are found constituting lava-streams, which are usually short and bulky; eruptive bosses or "Quellkuppen"; and lenticular intrusions or "laccolites."

By carefully following in the field the much-altered rocks to points where they retain some of their original characters, the propylites can be shown to represent various interesting types of andesite and diorite. The amphibolic and micaceous rocks include hornblende-andesites, hornblende- and mica-andesites containing enstatite, diorites, and quartz-diorites. Among the pyroxenic rocks the most noticeable varieties are the labradorite-andesites, the pyroxene-andesites—of which both "trachytoid" and "vitrophyric" forms occur—as well as examples of what have been called "diallage-andesites" (the nature of the pyroxene in which was fully discussed): these rocks are found passing into augite-diorites, and quartz-augite-diorites.

A microscopic study of these rocks enables us to investigate the processes by which they have acquired their peculiar characters. The chief and most widely operating cause of change is thus demonstrated to have been *solfataric action*; and this was shown to have accompanied the intrusion into the andesites of masses of igneous material of highly acid composition (granites and felsites). This solfataric action has been developed around each of the five volcanic centres described in 1874. A smaller and much more local cause of change—some of the results of which are strikingly contrasted with those of the wide-spread solfataric action—is found in the *contact-metamorphism* resulting from the intrusion into the andesites of masses of igneous rocks of basic, intermediate, or acid composition.

The much-altered propylites of Tertiary age were shown to have their exact analogues among the older (Palæozoic) lavas of Scotland and other districts. These rocks, which have been called "felstones," "porphyrites," etc., are andesitic lavas, some of which have suffered only from the action of surface-waters, while others among them must have been profoundly affected by solfataric action and converted into propylites, prior to the operation of the surface-agencies of change.

Forming a very striking contrast with the older Tertiary andesites (propylites), are the numerous scattered and generally small masses of rock which belong to a late period in the Tertiary, and constitute the youngest volcanic rocks of the British Islands. These rocks are found intersecting, in the form of dykes, the great sheets of olivine-basalt; or where poured out at the surface (as at the Sgùrr of Eigg and Beinn Hiant in Ardnamurchan), lie upon their greatly eroded surfaces. The rocks in question, which have the mineralogical constitution of augite-andesites, are remarkable for the wide variations in their aspect and chemical composition; and this was shown to result from *differences in the proportion of the crystalline and glassy constituents to one another*. Holocrystalline aggregates, of basic composition, are found passing, as the quantity of acid glass increases, into various "ophitic," "intersertal," and "pilotaxitic" types, finally assuming the "vitrophyric" form of "pitchstone-porphyries"—rocks which have a distinctly acid composition. The rocks of the Tertiary dykes in Southern Scotland and the North of England, which have been described by Dr. A. Geikie, Mr. Teall,

and other authors, were shown to agree with these later Tertiary andesites, both in their mineralogical constitution and in the peculiar phases which they present to us. The latest Tertiary ejections were shown in 1874 to bear the same relations to the five grand volcanoes of the Western Isles which the chains of "puys" in Auvergne do to the great central volcanoes of that district; and this conclusion is strikingly confirmed by petrographical studies of which the results were given in the present memoir.

CORRESPONDENCE.

AGE OF THE VOLCANIC SERIES IN SHROPSHIRE.

SIR,—In reference to the debate on a paper "On the Pebidian Yoredale Series of St. Davids," read by Prof. C. Lloyd Morgan before the Geological Society on the 8th inst., Prof. Blake is reported to have said that recent work in Shropshire "had shown that there was a volcanic series more satisfactorily classed with the Cambrian than with the underlying series." Though I have some familiarity with the older rocks of Shropshire, I am unable to call to memory any volcanic series that can by any reasonable stretch of imagination be referred to the Cambrian. If Prof. Blake refers to the Uriconian system, surely the most recent work tends to throw it further back from the Cambrian. But perhaps he will favour your readers with a few words of explanation.

CH. CALLAWAY.

SANDORE, WELLINGTON,
Jan. 16*th*, 1890.

GROUND MORAINES.

SIR,—I have just read in Professor James Geikie's Address to Section C, British Association, "Swiss geologists are agreed that the ground-moraines which clothe the bottoms of the great Alpine valleys, and extend outwards sometimes for many miles upon the low ground beyond, are of true glacial origin. Now these ground-moraines are closely similar to the Boulder-clays of this country [Britain] and Northern Europe."

We have in New Zealand, also, extensive deposits of ancient glaciers; but I have never seen in New Zealand anything corresponding to the Boulder-clays and stratified tills of Britain; and if this is correct, it would follow that Boulder-clays cannot be the ground-moraines of glaciers.

The subject is an important one, and I would suggest that the British Association should send some one to New Zealand who is an expert in Boulder-clays, to settle the question. Two months in Otago, Canterbury, and Westland, between November and April, and three months for the two voyages, would be sufficient time, and the cost would not be more than £200 or £250.

I do not know any more promising geological work at the present day than a comparison of the glacial deposits of New Zealand with

those of the northern hemisphere; but to be effectual, the comparison must be made by one who is well acquainted with the northern deposits.

F. W. Hutton.

Christchurch, N. Z., 12*th Nov.* 1889.

CORAL-LIKE STRUCTURES FROM THE CULDAFF LIMESTONE, CO. DONEGAL.

Sir,—I feel sure it will interest many of your readers to learn that the peculiar Coral-like structures from the Culdaff Limestone have recently been identified by Prof. James Hall, of Albany, and Mr. Charles Walcott, of the U. S. Geological Survey, as belonging to two genera of Palæozoic Corals, namely, *Columnaria* and *Tetradium*; forms which are often found together in the Hudson Group of America. These determinations have been arrived at, first, from photographs of specimens from the Survey Collection, but afterwards from five specimens selected and forwarded for examination. The determinations were independently made, and serve to confirm each other; and Prof. Hall gives a detailed diagnosis of each specimen.

I may add that similar determinations have been arrived at by Professors Dana and Ferd. Roemer from an inspection of photographs only. Descriptions of some of these forms will appear in the Geological Survey Memoir on Inishowen, North Donegal, now passing through the press. The identification of these forms by such experienced palæontologists as those above named must be regarded as of the highest importance in throwing light on the question of the age of the Donegal crystalline rocks; a question to which I hope to return at a future time.

Edward Hull.

Geological Survey of Ireland,
14, *Hume Street, Dublin.*

NOTE ON *PHLYCTÆNIUS*, A NEW GENUS OF COCCOSTEIDÆ.

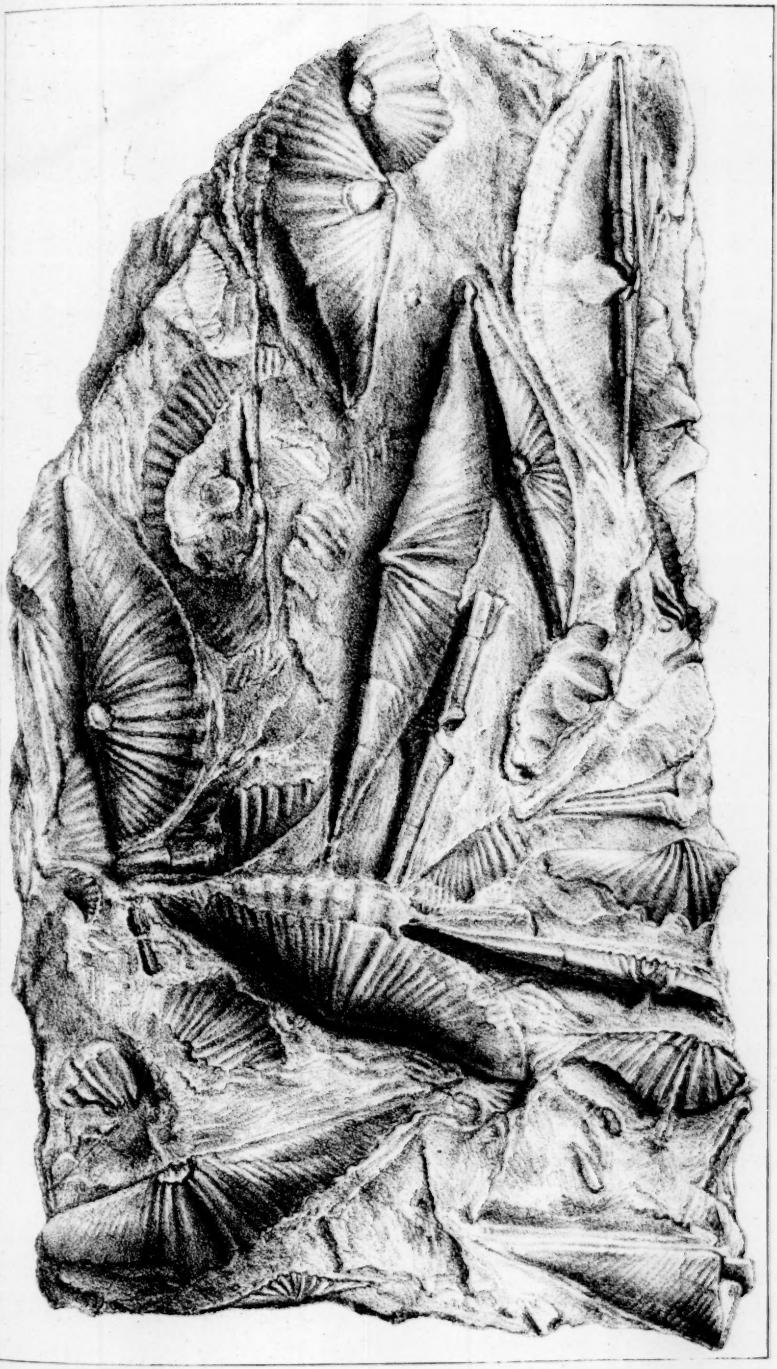
Sir,—As my friend Dr. Hinde has just called my attention to the fact that the name *Phlyctænius* has already, under the form *Phlyctænium*, been given by Prof. Zittel to a genus of fossil Sponges, I propose to substitute for it the term *Phlyctænaspis*, concerning which I can find no evidence of preoccupation.

R. H. Traquair.

RADIOLARIAN CHERT IN THE BALLANTRAE SERIES (=LLANDEILO-CARADOC) OF THE SOUTH OF SCOTLAND.

Sir,—Sections of this rock, just received from Mr. B. N. Peach, of the Geological Survey of Scotland, unmistakably show that it is mainly composed of Radiolarians. These bodies were first recognized in the chert by my friend Prof. H. A. Nicholson, but their real nature is only now conclusively shown in the sections sent me.

21 *February*, 1890. G. J. Hinde.



A.S. Foord del. et lith. West, Newman imp.

Spirifera lata *M'Coy.*

Carboniferous Sandstone, West Australia.

Locality.—Lyons River, a tributary of the Gascoyne River; Western Australia,[1] in a ferruginous and slightly micaceous sandstone.

SPIRIFERA HARDMANI, sp.nov. Plate VII. Figs. 1, 1*a*.

This species is of large size, and probably a little wider than high. The width of the hinge-area is a little less than that of the shell, the cardinal angles projecting slightly beyond the former. The cardinal angles are narrowly rounded. The hinge-area, as may be seen in Fig. 1*a*, is not large. The ventral valve is divided into two slightly rounded areas by a broad, rather shallow median sinus. Three or four ill-defined folds occur on the flanks of the shell on each side of the sinus. The shell is ornamented with numerous, rather strong, radiating ribs or plications, some of which bifurcate about midway between the umbo and the inferior border; these are intersected at intervals by lines of growth, and near the margin the shell developes numerous concentric, scale-like, imbricating laminæ.

In the interior of the ventral valve (Fig. 1*a*) a strong tooth is situated on each side at the base of the fissure, but the shelly plates supporting these are almost entirely destroyed, a portion of one only (right-hand side of figure) being preserved. The remains of a short septum are seen just beneath the beak. The impression of the cardinal muscles is obliterated in the figured specimen, but it is well seen in another fragment, less perfect in other respects. The surface outside the muscular area is covered with ramifying vascular impressions.

It is a singular fact that no remains of the dorsal valve of this species have been found, though the fragments of the ventrals are very numerous.

In one of the plates of a forthcoming work on Queensland Palæontology, by Mr. Robert Etheridge, jun., now of Sydney, New South Wales, there is a fragment of a shell which is certainly identical with the present species, with which it perfectly agrees. In the explanation of the plates, communicated by Mr. Etheridge to Dr. Henry Woodward, F.R.S., the fragment in question is designated *Spirifera trigonalis* [Martin], var. *crassa* (Davidson), de Koninck? But the doubt expressed by the note of interrogation shows that the suggested name for this fragment was only given tentatively.

The occurrence of the present species in Queensland is interesting as showing its tolerably wide geographical distribution.

Spirifera Hardmani is one of the few species among the Kimberley fossils which I am able to identify with some degree of certainty with a Queensland form, a circumstance to be accounted for probably by the fragmentary condition of the specimens hitherto obtained in Queensland.

The present species finds its nearest analogue in *Spirifera cincta*, von Keyserling,[2] but it is clearly distinguished therefrom by its

[1] See a short paper by F. T. Gregory in Quart. Journ. Geol. Soc. 1861, vol. xvii. p. 475; also the paper by W. H. Hudleston, F.R.S., in the same Journal, 1883, vol. xxxix. p. 582, already referred to.

[2] Wissensch. Beobacht. auf einer Reise in das Petschoraland im Jahre 1843,

straighter hinge-line, the lesser prominence of the beak of the ventral valve, and the more quadrate form of the shell.

Locality.—Gascoyne River.

SPIRIFERA MUSAKHEYLENSIS,[1] Davidson, var. AUSTRALIS, var. nov.
Plate VII. Fig. 2, and ? Plate V. Fig. 12.

1846. *Spirifer fasciger*, von Keyserling, Wissensch. Beobacht. auf einer Reise in das Petschoraland im Jahre 1843, p. 229, Tab. viii. figs. 3, 3*a*, 3*b*.
?1860. *Spirifer tegulatus*, Trautschold, Nouv. Mém. de la Soc. Imp. des Nat. de Moscou, tom. xiii. p. 354, "Die Kalkbrüche von Mjatschkowa," Taf. xxxv. figs. *a*—*g*.
1862. *Spirifera Moosakhailensis*, Davidson, Quart. Journ. Geol. Soc. vol. xviii. p. 28, pl. ii. fig 2, *a*—*e*.
1863. *Spirifera Moosakhailensis*, de Koninck, Fossiles Paléoz. de l'Inde, p. 34, pl. xi. figs. 2, *a*—*e* (copied from Davidson's, *loc. cit.*).
1865. *Spirifer Moosakhailensis*, von Martens, in Beyrich, Physik. Abhandl. der Königl. Akad. der Wissensch. zu Berlin (1864), Ueber eine Kohlenkalk-Fauna von Timor, p. 77, Taf. i. fig. 7.
1866. *Spirifera Moosakhailensis*, Davidson, Quart. Journ. Geol. Soc. vol. xxii. p. 41, pl. ii. fig. 5.
1887. *Spirifer Musakheylensis*, Waagen, Pal. Indica, Ser. xiii. Salt Range Fossils, vol. i. p. 512, pl. xlv.
1889. *Spirifer fasciger*, Tschernyschew, Allgem. geol. Karte von Russland, Blatt 139, (Mém. du Com. Géol. vol. iii. No. 4), pp. 353, 366, Taf. v. figs. 4, *a*—*c*.

The following is Davidson's description of this species:—"Shell transversely rhomboidal; valves almost equally deep or convex; hinge-line variable in length, sometimes not half as long as the breadth of the shell, while at times it is as long. Ventral area of moderate width; fissure wide and partially covered over by a pseudo-deltidium. Dorsal valve sub-linear; beak small and moderately incurved. In the dorsal valve there exists a wide, elevated angular fold, and in the ventral one a corresponding sinus. The whole surface of the shell is covered with numerous small ribs, which cluster into fasciculi, seven or eight being collected into groups, which give to the valves the appearance of a double plication, many of the smaller ribs being due to interpolation; while the whole surface and ribs are closely intersected by numerous sharp, projecting, concentric undulating laminæ, of which four or more may be counted in the breadth of a line. Dimensions very variable: a large example measured 26 lines in length by 39 in width and 18 or 19 in depth.

It was not until after much hesitation that I have ventured to propose a new name for the *Spirifera* under description. In external shape as well as by the grouping of the ribs it bears much resemblance to several known species of *Spirifera*, and especially to that figured in Owen's "Geol. Survey of Wisconsin and Minnesota"

p. 229, Tab. viii. figs. 2 *a*—*e* (1846). See also de Koninck, Faune du Calc. Carb. de la Belgique, 1887 (Ann. du Mus. Roy. d'Hist. Nat. de Belgique, tom. xiv.), pt. vi. p. 108, pl. xxiv. figs. 6, 7, and pl. xxvi. figs. 1—4. Recorded also by Th. Tschernyschew, Allgem. geol. Karte von Russland, Blatt 139 (Mém. du Com. Géol. vol. iii.-No. 4), p. 355.

[1] This word is written "Moosakhailensis" by Davidson, but I have adopted Waagen's spelling of it (Salt Range Fossils, Pal. Ind.), as being doubtless the more correct one.

(pl. v. fig. 4) under the name of *Sp. fasciger*, Keyserling?; but I partake of that author's doubts while referring the shell in question to de Keyserling's Russian species. It approaches also by its shape to certain examples of d'Orbigny's *Sp. Condor*, *Sp. cameratus*, Hall, as well as to some exceptional British specimens of *Spirifera striata*; but in none of these do we perceive, nor does any author describe the peculiar and beautifully regular, closely disposed, sharp, projecting, concentric, undulating laminæ, which resemble so closely those of *Sp. laminosa*, and which give to the shell its beautiful sculptured appearance. *Sp. Moosakhailensis* is common in the Punjab, at Moosakhail, Chederoo, Kafir Kote, etc."

The close resemblance of the Australian fossil to *Sp. Musakheylensis*, Dav. (the types of which are now before me), is at once apparent, and the only difference between them is that the ornaments of the Australian species are perhaps a little coarser than those of the Indian one, *i.e.* the former has slightly larger and consequently fewer small ribs (comparing together individuals of the same size) than the latter, and the imbricating lamellæ exhibit the same divergence of character. It seems, however, scarcely necessary to regard these slight differences as of more than varietal importance, especially when one takes into account the variations in any large assemblage of Brachiopods, as Davidson himself has so often demonstrated in his plates.

The synonymy of the present species is somewhat involved. Taking first *Spirifer fasciger*, Keyserl., we find that it is regarded by Th. Tschernyschew,[1] who had access to the type-specimen (or specimens), as identical with *Spirifera Musakheylensis*, Dav., and with another form which he describes and figures from the Southern Urals. The following is the passage in which he gives his views concerning these forms:—"I find," he says, "no sufficient ground for separating *Spirifer tegulatus*, Trautsch., from the Indian species [*Musakheylensis*], and from *Sp. fasciger*, Keyserl." The figures of the latter in Tschernyschew's plate are certainly in no way distinguishable from those of Waagen[2] in the "Palæont. Indica." Waagen, while admitting the very close relationship between *Spirifer fasciger* and *Sp. Musakheylensis*, finds that the ornaments in the former are coarser than those of the latter. In this respect, therefore, *Sp. tegulata* approaches the present variety. Waagen also observes that "if we set aside the lamellose character of the striæ of growth, then there is quite a number of species to which the present one might be compared," and that probably *Sp. fasciger* is the ancestral type of them all.[3]

It has been seen that Davidson failed to recognize the identity of his species with *Sp. fasciger*, because von Keyserling's specimens being only casts, one at least of the most important of the specific characters was wanting in them; but he seems to have overlooked Trautschold's species, in which the lamellose, imbricated striæ are

[1] See table of synonymy.
[2] Pal. Ind.—Salt-Range Fossils, 1887, vol. i. p. 512, pl. xlv.
[3] *Loc. cit.* p. 515.

clearly figured, an enlarged figure of them being given to show their structure.[1]

If now we regard *Sp. tegulata* of Trautschold either as a distinct species, according to Waagen, or merely as a variety of *Musakheylensis*, then Davidson's name would still hold good. If, on the other hand, Tschernyschew's views are correct, viz. that *Musakheylensis* and *tegulata* are one and the same species, the latter name, being of prior date, must take the place of the former. Waagen holds very decided opinions upon this point. He says, that "the peculiar sculpturing, so similar to that of *Musakheylensis*, has been excellently described and figured by Trautschold; but from his description and figures it can also be concluded with very great certainty that the two species are different. In *Spirifer tegulatus* the radiating ribs are much coarser, and the lamellose sculpturing more strongly developed than in the Indian form, and there is apparently but little doubt that the two species are different. Nevertheless, it is highly probable that the Russian species, which occurs in the Upper Carboniferous Limestone of Moscow, is the ancestor of the Indian shells."

After much deliberation, I have thought it best to leave the matter an open question, retaining for the present Davidson's name, which is now so widely current, for the species, making the Australian form a variety of it. Most probably the fossil described by von Martens from the Island of Timur belongs to the latter, the localities of the two forms not being very remote from each other.

The interior of a ventral valve figured on Plate V. (Fig. 12) may possibly belong to the present species, but the specimen is too imperfectly preserved to be determined with certainty.

Locality.—Gascoyne River.

SYRINGOTHYRIS EXSUPERANS, de Koninck, sp.

1877. *Spirifera exsuperans*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 249, pl. xv. figs. 1, 1*a*, 1*b*.
1878. *Spirifera exsuperans*, Etheridge, jun., Cat. Australian Fossils, p. 56.

There occur in the Collection numerous fragments of the hinge-plates of this species from the Gascoyne River. Being broken in a peculiar manner, these separate pieces were very puzzling, and I at first took them to be portions of a Lamellibranch; but my friend Mr. R. B. Newton, to whom I showed them, fitted some of the pieces together, and thus demonstrated their true nature.

Locality.—Gascoyne River.

ATHYRIS MACLEAYANA, Etheridge, jun. Plate VII. Fig. 3 (and Woodcut).

1889. *Athyris Macleayana*, Etheridge, jun., Proc. Linnean Soc. New South Wales, second ser. vol. iv. pt. ii. p. 208, pl. xvii. figs. 1—5.

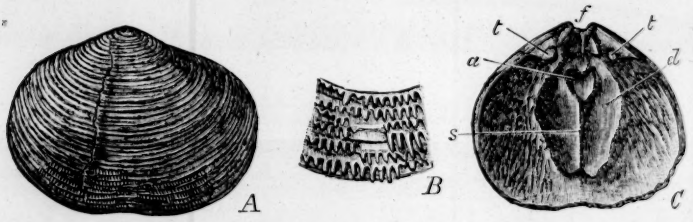
"Shell circular, or transversely oval in outline, but usually the former, plano-convex, or at times slightly concavo-convex, the ventral valve flat or slightly concave; the lateral margins are in the same plane with the hinge-line, but the front is to some extent

[1] Nouv. Mém. de la Soc. Imp. des Nat. de Moscou, 1860, tom. xiii. pl. xxxv. fig. 6*d*.

sinuated. Ventral valve flat as a rule, and very shallow, with an inconspicuous horizontal and semi-truncate umbo, but in no degree overhanging the hinge-line; foramen small, circular, opening upwards, but sometimes a little oblique; sinus very faintly shown on the surface of the valve, but indicated by a forward extension of the front margin. Dorsal valve moderately convex, evenly rounded in outline, with little or no distinction into fold and flanks; umbonal region far more marked than in the ventral valve. Surface of both valves with coarse, concentric, roughened laminæ.

"A very peculiar form of *Athyris*, from the persistent shallowness of the united valves, especially of the ventral. . . . . In one or two places the appearance of the concentric surface laminæ would lead to the belief that they projected as separate spines, after the manner of *Athyris Royssii*, Lév."

Nearly all the specimens in the Collection, with the exception of the one figured on Plate VII., are crushed, but it is plain that the valves were naturally much compressed, and none of them indicate, so far as one can judge, the amount of convexity of the dorsal valve of the specimen figured by Mr. Etheridge (*loc. cit.* figs. 3, 4). His description of this species agrees, however, so nearly with the specimens from the Gascoyne River, that I have scarcely any hesitation in referring them to it. I am fortunately enabled to give a figure of the interior of the ventral valve of the present species, which I have drawn on the wood, having succeeded in removing



Athyris Macleayana, R. Eth., jun., Carboniferous, Gascoyne River.

the matrix from one of the specimens. This supplements my brother's figure (Pl. VII. Fig. 3). Two other specimens show the interior of the same valve, and the matrix being somewhat friable, is easily cleaned out. The interior structures being thus readily laid bare will afford future collectors a valuable character for the recognition of the species. Only one of the specimens is sufficiently well preserved to show in some places the spines which ornamented the surface of the shell; in all the others these have been rubbed off, and no indication of them remains but a few faint longitudinal lines, such as are seen in Plate VII. Fig. 3, which is the external view of the same individual represented in the accompanying woodcut (*C*). In this it will be seen that the dental plates are united to the outer wall of the shell by a thick shelly callosity. The hinge-teeth (*t, t*) are strong and prominent, and apparently

bifid. The adductor impressions (*a*) are rather deep, beginning a little below the level of the hinge-teeth, and terminating at about the mid-length of the shell, where they meet a somewhat prominent ridge or septum (*s*) which extends nearly to the front margin of the valve. This septum divides the large and spreading impressions of the cardinal muscles (*d*) into two areas which occupy nearly one-third of the interior of the valve, and terminate in two short and narrow lobes at the bottom of the septum. The rest of the interior of the shell, with the exception of a narrow marginal zone, is covered with reticulated vascular markings, strong near the hinge-teeth, and becoming less pronounced towards the front margin of the valve.

I may add that the largest individual in the Collection measures 1 inch 2 lines in length, and 1 inch 5 lines in breadth.

A single, crushed specimen, with both valves, evidently derived from a different matrix from the rest, differs slightly from them in its greater relative breadth. This example is illustrated in the Woodcut (*A*), together with a portion of its shell-ornament (*B*), consisting of flattened spines, forming a fringe at the margin of the lamellæ of which the shell is composed. A similar spiny investment covers the shell of *Athyris Roysii*, to which the present species is probably nearly allied.

Locality.—Gascoyne River.

Carboniferous Fossils from the Irwin River, Victoria District.[1]

POLYZOA.

Fenestella.

Fragment of the non-poriferous aspect of a frond of a species of *Fenestella*, probably *F. ampla*, Lonsdale (Strzelecki's Phys. Descr. of New South Wales and Van Diemen's Land, 1845, p. 268, pl. ix. figs. 3, *a–d*).

BRACHIOPODA.

Productus tenuistriatus, de Verneuil. Plate VII. Figs. 4, 4*a*.

1845. *Productus tenuistriatus*, de Verneuil, Géol. de la Russie d'Europe, et des Montagnes de l'Oural, vol. ii. pt. iii. Paléont. p. 260, pl. xvi. fig. 6.

1889. *Productus tenuistriatus*, Tschernyschew, Allgem. geol. Karte von Russland, Blatt 139 (Mém. du Com. Géol. vol. iii. No 4), p. 372, Taf. vi. figs. 15, *a–c*.

There are a few examples of a species which agrees in all essential points with de Verneuil's *tenuistratus*. This species differs from others of the same genus by the fineness of its striæ, their irregularity, and the absence or rarity of the tubes with which the Producti are usually provided.

The irregularity of the ribbing is referred to also by Tschernyschew as one of the distinguishing characters of *tenuistriatus*, and he adds that there are intercalated ribs between the original ones. These are quite recognizable in the specimens under description.

Locality.—Irwin River, Victoria District.

[1] An explanatory note by Mr. H. P. Woodward to the following effect accompanied these fossils:—"Irwin River, Coal Seam, a little S.E of Champion Bay, about 30 miles from coast: sandy table-land, cut through by river, exposing ferruginous sandstones and conglomerate, resting unconformably on Coal-measure Series."

Productus subquadratus, Morris. Plate VII. Fig. 5.

1845. *Productus subquadratus*, Morris, in Strzelecki's Physical Description of New South Wales and Van Diemen's Land, p. 284.
?1847. *Productus subquadratus*, de Koninck, Mon. du Genre Productus, p. 203, Atlas, pl. xiv. figs. 1, *a–d*.
1878. *Productus subquadratus*, Etheridge, jun., Cat. Australian Foss. p. 53.
1880. *Productus subquadratus*, Etheridge, jun., Proc. Roy. Phys. Soc. Edinburgh, vol. v. p. 283.

Several tolerably well-preserved specimens are referred to this species mainly on account of the well-marked mesial furrow which distinguishes them, and is one of the chief characters in *subquadratus*.

Mr. R. Etheridge, jun. (Proc. Roy. Phys. Soc. Edinb. vol. v. 1880, p. 283), refers to de Koninck's opinion that the present species is only a form of *P. brachythærus*, G. Sow.,[1] but he does not say anything tending to confirm de Koninck's view. The specimen forming part of the Strzelecki Collection in the British Museum, and figured by Morris in Strzelecki's work on "New South Wales" (pl. xiv. fig. 4*c*, not figs. 4*a*, 4*b*),[2] assuredly cannot belong to the same species as the form named by Morris *P. subquadratus*, the type of which I have now before me. The ventral valve of the latter is extremely gibbous, and is divided into two prominent lobes by a very distinct mesial furrow, a character well displayed in Mr. H. P. Woodward's specimens. No such feature is to be found in *P. brachythærus*, nor has it apparently the numerous irregularly-disposed, conspicuous spine-bases with which the surface of *P. subquadratus* is beset. It would seem not improbable that the species doubtfully referred by Mr. Etheridge to *P. subquadratus* is, after all, not that one, because no mention is made of any mesial furrow in the description, which is so marked a character in Morris's species, and one therefore which could not possibly have been overlooked.

Locality.—Irwin River, Victoria District.

Productus undatus, Defrance. Plate VII. Fig. 6.

1826. *Productus undatus*, Defrance, Dict. des Sci. Nat. vol. xliii. p. 354.
1843. *Productus undatus*, de Koninck, Descrip. des Anim. Foss. du Terr. Carb. de Belgique, p. 156, pl. xii. figs. 2, *a—c*.
1845. *Productus undatus*, de Verneuil, Géol. de la Russie d'Europe, et les Montagnes de l'Oural, vol. ii. pt. iii. Paléont. p. 261, pl. xv. fig. 15.
1847. *Productus undatus*, de Koninck, Mon. du Genre Productus, p. 156, Atlas, pl. v. figs. 3, *a—c*.
1860. *Productus undatus*, Trautschold, Nouv. Mém. Soc. Imp. des Nat. de Moscou, tom. xiii. p. 329, Taf. xxxii. fig. 2.
1861. *Productus undatus*, Davidson, Brit. Carb. Brach. vol. ii. pt. v. p. 161, pl. xxxiv. figs. 7—13.
1877. *Productus undatus*, de Koninck, Recherches sur les Fossiles Paléozoiques de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 190, pl. ix. fig. 4.
1878. *Productus undatus*, Etheridge, jun., Cat. Australian Fossils, p. 53.

This well-marked and widely-distributed species is represented

[1] In Darwin's Geological Observations on Coral Reefs, etc. pt ii. 1851, Appendix, p. 158.

[2] Dr. H. Woodward, F.R.S., and Mr. Etheridge, jun., proved that these figures represent "a distinct and separate species," from fig. 4*c*, which is the true *P. brachythærus* (Proc. Roy. Phys. Soc. Edinburgh, vol. v. 1880, pp. 286, 287).

by specimens which show admirably the features characteristic of it, as may be seen in the one selected for illustration. The curious crumpled appearance of the concentric wrinkles on the surface of the shell is a feature which plainly distinguishes this species from all others, and has led to its recognition in many countries.

Locality.—Irwin River, Victoria District.

SPIRIFERA MUSAKHEYLENSIS, Davidson, var. AUSTRALIS, var. nov.

A small specimen of this variety showing its characteristic ornaments.

Locality.—Irwin River, Victoria District.

SYRINGOTHYRIS EXSUPERANS, de Koninck, sp. (supra, p. 149).

Fragments of the ventral valve of this species are contained in Mr. H. P. Woodward's Collection. They are clearly identical with the specimens from the Gascoyne River. One of them shows the large area with its triangular aperture, partly closed by the pseudodeltidium, and on the other side the ribbed shell with its deep mesial sinus.

Locality.—Irwin River, Victoria District.

RETICULARIA LINEATA, Martin, sp.

1809. *Conchilolithus Anomites lineatus*, Petrificata Derbiensia, p. 12, pl. xxxvi. fig. 3.
1836. *Spirifera lineata*, Phillips, Geol. of Yorkshire, pt. ii. p. 219, pl. x. fig. 17.
1842. *Spirifer lineatus*, de Koninck, Descr. des Anim. Foss. du Terr. Carb. de la Belgique, p. 270, pl. vi. fig. 5, pl. xvii. fig. 8.
1858. *Spirifera lineata*, Davidson, British Carb. Brach. vol. ii. pt. v. p. 62, pl. xiii. figs. 1–13.
1865. *Spirifer lineatus*, von Martens, in Beyrich, Physik. Abhandl. der Königl. Akad. der Wissensch. zu Berlin (1864), p. 76, Taf. i. figs. 13, *a–c*.
1877. *Spirifer lineatus*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 224, pl. xi. fig. 9.
1878. *Spirifera lineata*, Etheridge, jun., Cat. Australian Fossils, p. 57.
1887. *Reticularia lineata*, Waagen, Mem. Geol. Surv. India—Palæont. Indica, Salt-Range Foss. vol. i. ser. xiii. p. 540, pl. xlii. figs. 6–8.

Specimens of the ventral valve of this species are recognizable in the Collection.

Locality.—Irwin River, Victoria District.

RETICULARIA CREBRISTRIA, Morris, sp.

1845. *Spirifera crebristria*, Morris, in Strzelecki's Phys. Descrip. of New South Wales and Van Diemen's Land, p. 279, pl. xv. fig. 2.
1847. *Spirifera* (*Reticularia*) *crebristria*, M'Coy, Ann. and Mag. Nat. Hist. vol. xx. p. 232.
1854. *Spirifera crebristria*, Grange, in Dumont-d'Urville's Voyage au Pole Sud, Géol. vol. ii. p. 85.
1877. *Spirifera crebristria*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 225, pl. ix. fig. 5.
1878. *Spirifera crebristria*, Etheridge, jun., Cat. Australian Fossils, p. 55.

"Shell transversely elliptical, depressed; mesial fold rather large, rounded and undefined; surface marked with numerous, fine, radiating, closely approximated striæ, crossed by the faintly prominent lines of growth; width exceeding the length by one-fourth."

(Morris). The characteristic features of this species are fairly well shown in two or three examples.

Locality.—Irwin River, Victoria District.

Orthotetes crenistria, Phillips, sp.

1836. *Spirifera crenistria*, Phillips, Geology of Yorkshire, pt. ii. p. 216, pl. xi. fig. 6.
1860. *Streptorhynchus crenistria*, Davidson, Brit. Carb. Brach. vol. ii. pt. v. third portion, p. 124, pl. xxvi. fig. 1, pl. xxvii. fig. 1–5 and 10 ?, pl. xxx. figs. 14–16.
1865. *Streptorhynchus crenistria* ? Beyrich, Physik. Abhandl. der Königl. Akad. der Wissensch. zu Berlin (1864), p. 82, Taf. 1, figs. 9, *a*, *b*.
1877. *Orthotetes crenistria*, de Koninck, Recherches sur les Fossiles Paléozoiques de la Nouvelles-Galles du Sud (Australie), pt. iii p. 212, pl. x. fig. 8.
1878. *Orthotetes crenistria*, Etheridge, jun., Cat. Australian Fossils, p. 50.

This species is represented only by a fragment of a dorsal valve.

Locality.—Irwin River, Victoria District.

LAMELLIBRANCHIATA.

Pachydomus carinatus, Morris.

1845. *Pachydomus carinatus*, Morris, in Strzelecki's Physical Description of New South Wales and Van Diemen's Land, p. 273, pl. xi. figs. 3, 4.
1847. *Cypricardia rugulosa*, Dana, American Journ. Sci. vol. iv. p. 157.
1847. *Pachydomus carinatus*, M'Coy, Ann. Mag. Nat. Hist. vol. xx p. 301.
„ *Mœonia carinata*, Dana, in Wilkes's Expl. Exped. 1838–42, vol. x. Geology, p. 696, Atlas, pl. vi. figs. 1*a*, 1*b*.
1877. *Pleurophorus carinatus* ?, de Koninck, Rech. sur. les Foss. Paléoz. de la Nouvelles-Galles du Sud, pt. iii. p. 283, pl. xix. fig. 8.
1878. *Pachydomus carinatus*, Etheridge, jun., Cat. Australian Fossils, p. 74.
1880. *Pachydomus* (?) *carinatus*, Etheridge, jun., Proc. Royal Phys. Soc. Edinburgh, p. 300, pl. xvi. fig. 53.

The strong umbonal ridge makes this species easily recognizable. There are two or three small examples of it.

Locality.—Irwin River, Victoria District.

Undetermined Species.

The following genera also are probably represented among the Irwin River fossils, but the specimens are too imperfect for specific identification:—*Aviculopecten, Modiola, Edmondia, Sanguinolites.*

GASTEROPODA.

Bellerophon decussatus ?, Fleming.

1828. *Bellerophon decussatus*, Fleming, British Animals, p. 328.
1844. *Bellerophon decussatus*, de Koninck, Descrip. des Animaux Foss. du Terr. Carb. de la Belgique, p. 339, pl. xxix. figs. 2, 3, pl. xxx. fig. 3.
1877. *Bellerophon decussatus*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 366.
1878. *Bellerophon decussatus*, Etheridge, jun., Cat. Australian Fossils, p. 79.

There are several examples, mostly of the young, of a shell very much like Fleming's species, but only one of them has the test remaining, and in this the ornaments are not quite satisfactorily preserved.

Locality.—Irwin River, Victoria District.

CEPHALOPODA.

Orthoceras, sp.

A small fragment half an inch long, too imperfect to determine, showing a central siphuncle and seven of the septa.

Locality.—Irwin River, Victoria District.

Discites, sp.

A young example, somewhat crushed, of the type of *Discites* [*Nautilus*] *Omalianus*, de Koninck (Descr. des Anim. Foss. du Terr. Carb. de la Belgique, Suppl., 1851, p. 711, pl. lx. figs. 3, *a–c*). The specimen has the test preserved, and its ornaments consist of fine thread-like spiral lines crossed by very numerous, close-set transverse lines; the septa moderately distant, *i.e.* about two lines apart upon the peripheral face, where the transverse diameter is four lines. The greatest diameter of the fossil is 1 inch 2 lines.

Locality.—Irwin River, Victoria District.

EXPLANATION OF PLATES VI. AND VII.

PLATE VI.

A fine group of specimens of *Spirifera lata* (McCoy), in Carboniferous Sandstone from the Lyons River, a tributary of the Gascoyne River, West Australia.

PLATE VII.

Figs. 1, 1*a*.—*Spirifera Hardmani*, Foord, sp. nov. Exterior of ventral valve, and (1*a*) interior of ventral valve, showing hinge-area.

Fig. 2.—*Spirifera Musakheylensis* (Davidson), var. *Australis*, Foord, var. nov.

Fig. 3.—*Athyris Macleayana* (Etheridge, jun.), and see also woodcuts in text.

Figs. 1, 2, and 3, all from the Carboniferous of the Gascoyne River.

Figs. 4 and 4*a*.—*Productus tenuistriatus* (de Verneuil).

Fig. 5.—*Productus subquadratus* (Morris).

Fig. 6.—*Productus undatus* (Defrance).

Figs. 4, 5, and 6 all from the Carboniferous of the Irwin River, Victoria District.

II.—Physiography of the Lower Trias.

By T. Mellard Reade, C.E., F.G.S.

THE origin of the Lower Trias is evidently a question of interest to the readers of the Geological Magazine. Professor Bonney,[1] in an article, to the tone of which no exception can be taken, criticizes the view which I have ventured to put forth,[2] and very properly supports his own. It would be impossible and a waste of paper and type for me to traverse all his statements, as in many cases my reply would amount to little more than a reproduction, in a different form perhaps, of the arguments already made use of. There are, however, one or two points on which I should like to express myself, and there are some misconceptions that require clearing up.

Professor Bonney holds pretty strongly to the view that the pebbles of the Bunter have come from Scotland, and says, "I entirely fail to see any improbability in regarding the Pennine Chain as an upland which separated for a time the valleys of two

[1] Geol. Mag. Feb. 1890, pp. 52–5. [2] *Ibid*, Dec. 1889.

rivers draining the mountainous region to the north." As I have not done so in my original paper, I will now deal specifically with this notion.

The first difficulty in accepting it arises from the generally sparse distribution of the pebbles throughout the Bunter Sandstones of Lancashire and Cheshire, combined with the much greater development of conglomerate beds further South and in the Midland Counties. It is true that there are certain horizons in the Bunter of Lancashire and North Cheshire containing pebbles which have been dignified with the term "conglomerates" to distinguish them from the more prevalent homogeneous sandstones: but of genuine conglomerate, such, for instance, as may be seen at Market Drayton and Bridgnorth, there is a great absence.

Indeed, so much so is this the case that I am about to exhibit at the Liverpool Geological Society a block of conglomerate taken from a bed only nine inches thick disclosed by sewer excavations in Church Road, Walton.

If the pebbles were generally derived from the north by river transport, we should expect to find the conglomerate beds increasing in thickness and the pebbles in size in that direction. The contrary is the case.

Then as to the sand:—an inspection of the geological map of Scotland shows such a diversity of rock-structure, and there exist such lithological differences in the various areas that would have drained into these two hypothetical rivers, as to seem irreconcilable with the required travel of sand only, southwards.

To speak fairly, this is a difficulty that affects more or less any hypothesis, but it is doubly intensified on the subaerial and river theory of the origin of the Bunter Sandstones.

It will be seen that Prof. Bonney misconceives the facts in speaking of the Bunter generally as a "conglomerate." It is in Lancashire and Cheshire essentially a *sandstone*, and many of the so-called "pebble beds" do not possess a single pebble! Prof. Bonney writes from a locality where he is under the influence of "a practically unbroken pebble-bed at least thirty yards thick"; but this is in Staffordshire, and I claim the fact as being more in unison with my view of the marine origin of the Bunter than with its possible derivation from the north by river action. Such a conglomerate bed does not to my knowledge exist in the Trias anywhere between here and Scotland.

I do not know whether Prof. Bonney has read the two papers referred to on "Tidal Action." If not, he may possibly on perusal alter his views as to the efficiency of tides to move such pebbles as are found in the so-called "Pebble Beds."

There is, I know, great misconception prevailing on the subject of tidal action. The writers of geological text books, judging from all that I have read, and I have examined many, are mostly "quite at sea" on the tides, and seek to confine their effects to the shore! Prof. Bonney asks, "Is there any evidence that these currents would be capable of sweeping about pebbles 3 or 4 inches in diameter?"

to which I answer, "Yes, plenty," but also add that such a size is not common in the Bunter of Lancashire and Cheshire.

According to the experiments of Mr. Blackwell,[1] made in a trough of elm 60 feet long, 4 feet wide, and 3 feet deep, set horizontally, a current of water having a velocity of from 105 to 125 feet per minute, started a boulder weighing 11·87 ozs., and with a current of from 165 to 180 feet it was carried along at the rate of 90 feet per minute. These velocities, the lowest about a knot per hour, and the highest rather less than two knots, are, as I have shown, frequently exceeded by tidal currents, and the size of the boulder in question is far above the mean of those of the Pebble Beds.

Captain Beechy, who investigated the tides of the Irish Sea, says of the tide entering the North Channel, "The *main body* sweeps to south by east, taking mainly the general direction of the Channel, but pressing more heavily on the Wigtonshire coast; *off which it has scooped out a remarkable ditch upwards of* 20 *miles long by about a mile only in width, in which the depth is from* 400 *to* 600 *feet greater than the general level of the bottom about it.*" Again, between Glas Island and Sqeir-i-Noe, in the Little Minch off the west coast of Scotland, the flood-stream often takes the buoys of the long lines down; "and it is a remarkable circumstance indicative of the great depth of the tidal stream here, that the buoys, though anchored in 70 or 80 fathoms, are taken completely to the bottom; star-fish and other marine animals being found attached to them."[2] These instances might be multiplied, but there are evidences of strong currents at much greater depths in the ocean; for instance, while laying the Falmouth Cable near Gibraltar at 500 fathoms, "the wire was ground like the edge of a razor, and we had to abandon it and lay a cable well in shore."[3] These facts will be found fully detailed in a paper on "Tidal Action as a Geological Cause" (Proceedings of Liverpool Geol. Soc. 1873–4), and "Tidal Action as an Agent of Geological Change," Phil. Mag. May, 1888.[4]

One of the characteristics of the pebbles of the Bunter is their extreme smoothness and roundness, and I venture to suggest that the rolling about by tidal action from day to day amongst siliceous sand, together with the wash of sand over and against them, would produce more efficacious polishing and give more travel than even the longest river we may postulate. But it is not to be assumed that all the pebbles were polished in deep water; for if the beds are marine in origin, littoral deposition and wave action are not excluded.

I think I have now answered the most material parts of Professor Bonney's useful criticisms, and as I have no personal observations to record on the Nagelflue and Molasse, to which he compares the Bunter, I must refrain from any observations thereon.

[1] These were made for the Referees of the Metropolitan Drainage.

[2] Sailing Directions for the West Coast and Islands of Scotland, from the Mull of Cantyre to Cape Wrath, p. 119.

[3] Extract from letter from Sir Jas. Anderson to the writer.

[4] See Mr. Arthur Hunt's letter on "Tidal Action," *infra*, p. 191.—Edit. Geol. Mag.

III.—On a New Species of Pycnodont Fish (*Mesodon Damoni*) from the Portland Oolite.

By A. Smith Woodward, F.G.S., F.Z.S.

THE Fossil Fishes of the English Portlandian Formation are as yet almost unknown, and every small contribution to the subject is thus of interest. *Ischyodus Townsendi*,[1] *Microdon pagoda*,[2] the partially described *Caturus angustus*,[3] an undetermined species of *Thrissops*,[4] and an undescribed species of *Mesodon*,[5] appear to be the only forms hitherto recorded; and to these may be added a large bony fish allied to *Ditaxiodus*, represented by jaws in the British Museum.

The species of *Thrissops* and the isolated jaws just mentioned require longer study and more detailed comparison than the present writer has yet been able to undertake for their satisfactory determination; but the dentition of *Mesodon* seems to be so common and typical a fossil of the Portland Beds, exhibiting such well-marked characters, that it will be convenient at once to apply to the fish it represents a defined specific name. Mandibular rami with teeth of the form here referred to have been recorded in error under the name of "*Pycnodus Bucklandi*, Ag."; and a figure of one fine specimen, now in the British Museum, is given in the Supplement to Mr. Robert Damon's "Geology of Weymouth," pl. viii. fig. 9. This fossil is a left splenial bone, showing nearly all the teeth in position, and its principal characters are repeated in five other specimens in the same collection.

The bone in question is comparatively short and broad; and the teeth of the principal series are transversely elongated, not less than twice as broad as long. These teeth are regularly arranged, with narrow interspaces, and the outer extremity of each is somewhat broader and more truncated than the inner extremity, which exhibits a slight tendency towards tapering. The inner series of rounded teeth is relatively larger than usual in the genus, and is irregularly spaced; while still nearer the inner border are five smaller round teeth, with no definite regular arrangement. The outer teeth are smaller than those of the principal inner row, and seem to be disposed in three close but indefinite series, with a trace of a fourth marginal series; they vary in size and form indiscriminately, some being imperfectly hemispherical and others transversely elongated; and none exhibit a direct linear arrangement, although the median of the three series is marked by its teeth being of slightly less size than those of the other two. In another specimen the fourth or outer marginal series

[1] Sir Philip Egerton, Proc. Geol. Soc., vol. iv. (1843), p. 156. E. T. Newton, Chimæroid Fishes, Brit. Cret. Rocks (Mem. Geol. Survey, 1878), p. 33, pl. xi.

[2] Smith Woodward, Geol. Mag. [3] Vol. VI. (1889), p. 454. *Pycnodus pagoda*, J. F. Blake, Quart. Journ. Geol. Soc., vol. xxxvi. (1880), p. 228, pl. x. fig. 10.

[3] L. Agassiz, Poiss. Foss., vol. ii. pt. ii. (1843), p. 115.

[4] Smith Woodward, Geol. Mag. [3] Vol. VI. (1889), p. 455.

[5] Woodward and Sherborn, Cat. Brit. Foss. Vertebrata (1890), p. 121. *Pycnodus Bucklandi*, J. F. Blake (*non* Agassiz), Quart. Journ. Geol. Soc., vol. xxxvi. (1880), p. 227, and R. Damon, Geol. Weymouth (1860–88), Suppl., pl. viii. fig. 9.

is observed to extend along the posterior half of the bone, disappearing in the anterior half.

On comparing this form of dentition with that from the Lower Oolites named *Pycnodus didymus*, Ag.—which is most probably the lower jaw of *Mesodon Bucklandi*—it will be seen that the Portland fossil is distinguished (i.) by having the inner series of teeth relatively larger, (ii.) by exhibiting part of a supplementary inner row, and (iii.) by displaying the outer small teeth in three series, with half of a fourth series, all very irregularly arranged. Such differences may certainly be regarded as of specific value; and these characters also appear to separate the present fossil from all other jaws of *Mesodon* hitherto described. The most nearly related form is *Mesodon Nicoleti* (Ag.), from the Portlandian of Soleure, Switzerland. This species, however, is not satisfactorily defined, being apparently founded on an imperfect mandibular ramus with abnormally developed outer teeth; and if certain specimens in the British Museum, obtained from Soleure and probably referable to *M. Nicoleti*, are correctly so determined, the specific distinctness of the Swiss form from the English fossil is shown (i.) by the relatively smaller size of its inner teeth, (ii.) by the absence in it of a partial supplementary series inside and of a fourth series outside, and (iii.) by the greater regularity in the arrangement of its three rows of outer teeth.

Under the circumstances, the *Mesodon* of the English Portlandian may appropriately receive the name of *M. Damoni*, in memory of one of the most successful explorers of that formation, who first made known the fossil jaw by publishing a good figure.

IV.—On *Cœlacanthus Phillipsii*, Agassiz.

By James W. Davis, F.G.S., F.L.S.

THE late Prof. Louis Agassiz, whilst on a visit to Halifax with Prof. John Phillips, during the years in which he was preparing his "Recherches sur les Poissons fossiles," identified the caudal extremity of a large species of Cœlacanth fish to which he appended the name of *Cœlacanthus Phillipsii* in honour of his friend. The specimen is from a large "baum-pot," as the calcareous nodules are locally termed, obtained from the Lower Coal-measures. This specimen was found at the Swan Bank Pit at Halifax, and, so far as I know, is the only one which has been discovered. The surface exposed by splitting the nodule is 0·295 m. diameter, and the part of the fish preserved extends across it; it consists of the caudal portion of a large individual, which, had it been perfectly preserved, would have been between four and five feet in length. The vertebral axis extended in a straight line across the surface: its constituent parts are not preserved, but the distance between the neural and hæmal spines indicates a vertebral column of considerable size and power. Attached to the vertebral column are about thirty rays above, and a similar number below, which will probably indicate the same number of vertebral segments. The first caudal fin is

supported by neural and hæmal spines, interspinous bones, and fin-rays. The spines at a distance of 0·160 m. from the extremity of the anterior fin have a length of 0·050 m.; further back they decrease in length, and extend at a more acute angle with the axis of the body. The proximal end of each spine is bifurcated and broadly expanded for attachment to the cartilaginous column; the distal extremity is clavate with a flattened extremity. The proximal extremities of the interspinous bones are similarly clavate, and the flattened ends of each were joined together by a cartilaginous envelope. The interspinous bones apparently thin out to a point in the opposite direction, and the method of their attachment to the rays is not very clear. The rays do not afford any evidence of the bifurcated extremity embracing the interspinous bones, described by Agassiz as pertaining to *C. granulosus*, but appear rather to form a sort of splice with it. The fin-rays are articulated, and repeatedly bifurcate; their distal extremities are fine and slender. The posterior part of the tail, as represented in this specimen, somewhat disturbed and imperfect, indicates a breadth of 0·160 m. The second expansion of the caudal fin is not represented. A number of neural and hæmal rays occupy the space between the origin of those supporting the tail and the margin of the baum-pot; they are long and slender and deeply bifurcated for attachment to the vertebral axis; and the rays are hollow, but to a less extent than those of *Cœlacanthus Tingleyensis*, Davis,[1] which, however, are thicker in comparison to their length than are these. Agassiz remarks that the caudal fin is rounder than in *Cœlacanthus granulosus*, Agass.;[2] but it is more than probable that the round appearance of this specimen is due to its imperfect preservation.

A large number of scales are preserved; those on the anterior part are 0·100 m. in diameter, more or less circular behind, and ornamented with raised lines of enamel where the external surface is exposed. Most of the scales, however, are seen from the under side, as the result of the manner in which the nodule has split, and these exhibit a series of concentric lines parallel with their posterior border. Amongst the scales are two or three dissociated plates 0·30 m. across, which are exposed on the under side, and covered with concentric lines similarly to the smaller scales. The extension of the vertebral axis posteriorly between and beyond the lobes of the caudal fin is enveloped in smaller scales similar to those further forward, but only about half the size. There is no trace of other fins than the caudal.

Otto M. Reis, in a recently published memoir on "Die Cœlacanthinen,"[3] has separated from the genus *Cœlacanthus* all those species with striated scales which occur in the Coal-measures; retaining those from the Permian formations, with *Cœlacanthus granulosus* (non *granulatus*), Agass., and *C. Hassiæ*, Münst., as types, and with them *C. caudalis*, Eg., and *C. elongatus*, Huxley. The species excluded, viz. *C. lepturus*, Ag., *C. elegans*, Newb., *C. ornatus*, Newb.,

[1] Trans. Linn. Soc. vol. ii. p. 427.
[2] Poiss. foss. vol. ii. p. 172, pl. xlii.
[3] Palæontographica, vol. xxxv. 1888.

C. robustus, Newb., *C. Phillipsii*, Ag., *C. Huxleyii*, Traq., and *C. Tingleyensis*, Davis, are transferred to a new genus, *Rhabdoderma*. After a careful comparison of the species now described with the typical *C. granulosus* figured by Agassiz, there does not appear any generic difference in them to warrant such a separation.

The Halifax Hard-bed Coal rests on the Ganister rock and Seat earth used for making fire-bricks; it is an impure Coal containing iron in the form of pyrites, and not unfrequently nodules of the same substance. Rounded concretions containing carbonate of lime are also found in the Coal. Both contain vegetable remains in a beautiful state of preservation; when cut for microscopical examination, minute details of structure are exhibited with marvellous fidelity. Immediately above the Hard-bed Coal is a stratum of laminated shale, which is in some localities almost entirely composed of the fossil shells of marine genera, including a large proportion of *Aviculopecten*. The bed is about four inches in thickness; above, it is succeeded by a bed of shale four to six feet thick, containing a considerable number of nodular concretions, composed of carbonate of lime, with an outer covering of iron pyrites. These when broken are found to contain great numbers of remains of mollusca of the marine genera *Goniatites*, *Nautilus*, *Bellerophon*, *Orthoceras*, *Nucula*, *Aviculopecten*, and others less common. Fossil fish remains are also found associated, and it is in one of these balls that the example of *Cœlacanthus Phillipsii* was found. Scattered over the surface of the nodule are shells of *Goniatites*. From its association with these marine mollusca there appears to be no doubt that *Cœlacanthus* existed in salt-water during the formation of the Lowest Coal-measures. This is interesting for comparison with *C. Tingleyensis*, Davis, found in the Cannel Coal at Tingley, which is in the Middle Coal-measures. The Cannel Coal was deposited in a series of lake-like lagoons, the bottom of which were filled with fresh-water bivalves of the genus *Anthracosia*. The remains of *Cœlacanthus* occur in great abundance, and it lived at this time in fresh-water. The specimen of *C. granulosus*, Agass., was obtained from the Magnesian Limestone of East Thickley, in Durham, which is of marine origin.

V.—On the Schists of the Lizard District.

By Alexander Somervail, Esq.

Introduction.

THIS paper is intended as preliminary to one shortly to follow on the nature and origin of the banded structure in these rocks.

I have deemed it necessary to treat of the present subject as introductory to the other, giving my own views as to what I believe to be the true origin and relations of these rocks to each other, as these seemed to me to have a very direct and important bearing on the question of their banded structures.

Under the term schists used in the title I include all the rocks composing the "granulitic," "hornblendic" and "talco-micaceous"

groups of Prof. Bonney, F.R.S., and Sir H. De la Beche. Although separated into this triple division, I quite agree with the Professor that these "form but one series." I cannot, however, regard them as forming a strictly ascending or descending series in the order enumerated; neither am I certain that one of the groups, the "talco-micaceous," can any longer be regarded as a separate and independent group in itself for reasons to follow.

I shall briefly notice the leading petrological characters of each group of rocks, referring the reader to the elaborate descriptions of Prof. Bonney[1] and Mr. J. J. H. Teall,[2] M.A., F.G.S., for minute information.

I. The Granulitic Group.

This group was founded by Prof. Bonney to receive certain rocks held by him to form the uppermost of the three series, and composed "of greyish granitoid rocks, composed mainly of quartz and felspar, sometimes almost a quartzite, sometimes almost simulating a vein-granite, associated with more hornblendic, chloritic, earthy and micaceous layers."

These "granulitic" rocks throughout the entire extent of the area certainly form a very large variety, ranging from a rock scarcely discernible from an ordinary granite, to dark compact diorites, the latter frequently highly porphyritic. There are also quartzo-felspathic varieties in which one or other mineral predominates, sometimes with the addition of hornblende in variable quantities. Other varieties consist simply of pure felspar, or nearly so, from a granular, to a fine homogeneous texture. These might be classified under granites, granulites, tonalites, quartz-diorites, and diorites. Nearly all of these varieties occur in more or less extensive or isolated masses, and frequently pass by transition into each other. They also occur in many areas of the district interbanded together, aptly described by Mr. Teall as the "crystalline banded series."

II. The Hornblendic Group.

These rocks for the most part consist of dark hornblende schists and more compact varieties of rock resembling diorites with a complete transition between both. A porphyritic structure more or less abounds in certain areas throughout both the rocks and schists. In the latter, as would be inferred, this structure frequently exhibits the effects of crushing.

Besides these normal hornblendic rocks, which form the bulk of this group, there are, however, many other varieties associated with them, such as mica-schists, felsitic-like-rock, quartzose and quartzo-felspathic varieties approaching the granulitic type. Although these are certainly very subordinate, yet they must be taken into account in dealing with the origin and relations of these rocks as a whole.

Mr. Howard Fox, F.G.S., was, I believe, the first to discover mica-schists (resembling those at Polpeor Cove) in the very heart of the hornblende area at Pen Olver, Trecrobin and Polledan. These mica-schists, which have been carefully measured and

[1] Q.J.G.S. vol. xxxiii. p. 884; vol. xxxix. p. 1. [2] British Petrology.

mapped by him, are in beds of considerable thickness, and occur on several horizons in the hornblende-schists.

There is also the felsitic-like-rock at Housel Cove,[1] described by myself as an altered hornblende-schist, but which, I meant to have added, might have been the original rock in a more or less altered form, out of which the hornblende-schist had been made.

Still further, among the dark hornblendes of Pradnack we find quartzose and quartzo-felspathic varieties, and even a rock approaching the granulitic type south of the serpentine junction near Rynian. There are also small bands of felspar and quartzo-felspathic matter in the hornblende-schist at the landing-place in Landewednack Church Cove, which, however limited in extent and thickness, have yet their own bearing.

All these rocks are more or less connected by a passage into each other, and the whole in turn pass into the rocks of the "granulitic" group, from which they cannot be separated.

III. Talco-Micaceous Group.

This group of rocks was originally described by Mr. Majendie,[2] Dr. Boase[3] and De la Beche,[4] and is principally confined to the extreme south-west coast between Polpeor Cove and Caerthillian; a line between these two localities drawn inland being represented on the Survey Map as the boundary separating this group from the hornblendic.

With the addition of the outlying rocks described by Messrs. Teall and Fox,[5] which are certainly connected with those of the mainland, this group seems to me to be nothing more than the mere altered states of the two former groups, the "granulitic" and "hornblendic." The rocks which compose it, in their less altered conditions are essentially on the one side those of the quartzo-felspathic or "granulitic" type, and on the other, those of the "hornblendic." It is quite true that there are rocks differing widely from both, such as the mica-schists, mica-diorites, actinolitic-schists, chlorite-schists, etc.; but if these can be shown to be but an altered form of the "hornblende" group—as I think it can—it will simplify very much the geology of this complicated area.

Again, all the above-mentioned rocks, along with intermingled masses of less altered hornblende, are seen to shade into each other in the most perfect manner, almost in every locality in this area a passage being noted from one to another. There is sometimes a transition from the compact hornblende to the greenish schist, as seen near, or between Pentreath Beach and Caerthillian, other examples extending as far as Polpeor Cove; passages from the hornblende into chlorite-schist as at the Crane, from the former rock into actinolitic-schist at the Lizard Head, and into mica-dioritic, and this into mica-schist, at the same and many other localities.

[1] Geol. Mag. Decade III. Vol. VI. p. 114 (1889).
[2] Trans. Geol. Soc. of Cornwall, vol. i. p. 34 (1818).
[3] Trans. Geol. Soc. of Cornwall, vol. iv. p. 341 (1832).
[4] Report Com. Devon, etc. p. 29 (1839).
[5] Quart. Journ. Geol. Soc. vol. xliv. p. 309.

There are also as good evidences to show that these rocks—if they do not pass directly into—form part and parcel with those at the base of the Lizard Head, and the outlying rocks, which may well be claimed as granulitic, the whole having in my opinion a common age and origin, although differing widely in their lithological aspects. A transition, however, can be noted between the greenish or actinolitic-schist and the hornblende, and hornblendic, and granulitic gneissic rocks of the reefs. Many such like transitions have been noted and described by Messrs. Teall and Fox in their joint paper already referred to.

To my mind it seems quite clear that these "talco-micaceous" rocks have no separate existence apart by themselves, but are for the most part formed out of the "hornblende" series, by severe mechanical pressure and accompanying chemical change. Mr. Teall[1] has most correctly described this very area as a zone of intense dynamic metamorphism, and I think it is almost impossible for any observer not to note the fact, that here, more than in any other portion of the district, the original structure, texture and mineral constituents of these rocks have been wholly changed and replaced by secondary products to a very high degree.

The argument of their distinctness as a group drawn from their infra-position to the "hornblendic" and "granulitic" rocks,[2] is, I think, quite fallacious, as this is based on their treatment as a stratified series of deposits having an ascending rise from south-west to north-east, which however is only a system of divisional and cleavage planes, from which neither the true thickness, nor yet the true positions of the several masses of rock can be correctly estimated.

Provisionally, then, we shall take for granted the non-existence of the talco-micaceous group, regarding it meanwhile as but altered portions of the two former, which, right or wrong, will not however materially affect the points at issue in this paper.

IV. Origin of the Granulitic and Hornblende Groups.

As to the correct nature and origin of the rocks making up these two groups, there is considerable diversity of opinion.

Prof. Bonney[3] in his subsequent and modified views is still inclined to regard considerable portions of the rocks in each group as of sedimentary origin.

Mr. Teall inclines to similar opinions, but seems to restrict those rocks which he believes to be of sedimentary origin to a much smaller compass than is done by the former observer.

General McMahon,[4] F.G.S., in his recent able contribution to this subject, expresses the opinion that a certain portion, or portions of each group is made up of volcanic ashes and lavas.

If I may here venture an opinion of my own as to the exact mode of origin of these rocks, it is that there are no true tuffs or lavas, but that the whole are essentially rocks of plutonic origin. This

[1] Notes on the Lizard, from the Long Excursion of the Geologists' Assoc. for 1887.
[2] Quart. Journ. Geol. Soc. vol. xxxix. p. 5.
[3] Q.J.G.S. vol. xlv. p. 543.
[4] Q.J.G.S. vol. xlv. p. 519.

opinion is entirely based on field observations, and on the macroscopic aspects of the rocks, and also on the absence of any positive proof as yet furnished by the microscopists to lead to an opposite conclusion.

V. Relations between the two Groups.

There is also considerable diversity of opinion prevailing with regard to the relations between both groups, and the rocks which compose each, especially the rocks making up the "granulitic."

General McMahon in his paper referred to speaks of the "granulitic" group as containing many intrusive rocks, injected at different times, such as ordinary diorites, also a later porphyritic diorite, and still later veins of granite which traverse the whole.

It seems to me that if we were to eliminate both from the "hornblende" and "granulitic" groups these injected diorites and granite veins, we would almost, if not altogether, remove the whole of the rocks composing them. The porphyritic structure even in the hornblende group is much more common than was suspected, and I think it is by no means certain that there is any distinction in points of origin and age between the porphyritic and non-porphyritic varieties, even in both of the groups. Neither do I think it certain that the so-called granite vein portion of the "granulitic" group, such as we see at Kennack and elsewhere, has had a distinct and separate origin from the diorites.

Mention of the fact has already been made that the rocks making up the "hornblende" and "granulitic" groups vary from a diorite to one of granitic type, but between these two extremes there are however other rocks of an intermediate nature forming what I regard as a transition between both of these extremes, and associated with them in such a way as to bind them together into one natural group, having a common age and origin.

There are certainly areas, such as the foreshore of Kennack Cove, which might be selected as proof of the intrusion of the granite-like rock into the diorite; but, even here, it can equally well be read in the reverse way, so confusedly mingled together are these two varieties of rocks, and so often do they alternate with each other. As soon however as we leave the foreshore for the cliff of serpentine, we find both of these rocks combined together in varying proportions thrust through it. Not only is this so in several of the dykes in the Kennack area, but in many dykes throughout the whole of the Lizard district. In the dykes these rocks are so mixed up and banded together that some other explanation than their separate intrusions must be sought for. In my opinion this explanation is found in the separation of the basic and acidic portions of the magma while in the act of cooling, as pointed out in my short paper on the North Pentreath dyke ;[1] or it may be the case that, during the eruption of these rocks, acidic and basic magmas were being simultaneously belched forth together, preserving a partial separation; but, as we shall presently see, there

[1] Geol. Mag. Decade III. Vol. V. p. 553 (1888).

seems good reason for supposing that the one magma may have contained within itself the elements of the whole, which became ultimately more or less differentiated.

In many instances, as at West Kennack Cove, the highly interesting and instructive Kildown Cove, and other localities, there are rocks quite intermediate in character and composition between the granitic and dioritic types. These rocks are in close juxtaposition to both granite and diorite, and decidedly form a portion of them, the whole rising together through the adjoining serpentine. These intermediate rocks frequently form great homogeneous masses without any intermingling of other varieties, or without any banded structure whatever. They are only semi-granitic or granular in texture, and in composition contain hornblende, quartz, felspar, and perhaps a little mica; yet they are neither granites nor diorites proper: still, from this stage, we can trace them into both, also into varieties with a well-defined banded structure, in which sometimes the granitic and sometimes the dioritic constituents predominate.

Such intermediate varieties of rock are frequently found both on the coast and in inland directions rising through the serpentine. A dyke of this description, cutting through the serpentine, occurs at Trelease Moor, from which might be collected several distinct varieties of rock, ranging between the granitic and dioritic types. On the coast, as immediately east of the Yellow Carn and at many other localities, there are groups of dykes close together penetrating the serpentine, which I believe to be all related, which likewise vary from the dark compact dioritic type to the "granulitic" or granitic variety.

At Kildown Cove, near the centre of the "granulitic" mass which there appears to me to cut the serpentine, is a rudely circular and concretionary-like nodule, made up of concentric layers of alternating "granulitic" and dioritic rock, with a central nucleus of granitic material, in which are also patches of hornblende. The teaching of this singular and instructive complex nodular mass appears to me not only to have a very decided and direct bearing, not only on the origin and relations of these "granulitic" and "hornblendic" rocks, but also on the origin of these banded structures.

The important question now arises, are these "granulitic" or granitic and dioritic dykes portions of the great masses representing these two groups? My own observations incline me to reply that they are, for the following reasons:—

1st. The similarity, if not the exact identity, between the rocks composing the dykes and those forming the two groups proper.

2nd. The apparent connexion between the dykes and large masses of admitted granulitic and hornblendic rocks which seem to be their feeders.

3rd. The entire absence of these, or similar true eruptive[1] dykes, cutting the massive portions of either of the two groups,[2] which we

[1] The dykes in the outer rocks off the Lizard Head seem to me to be segregation dykes.

[2] Attention to this has been drawn by Mr. Teall.

might reasonably have expected to find, had the dykes been a separate and later product.

When we come to examine these "granulitic" and "hornblendic" rocks in their massive conditions and relations, and not confined to mere dykes or small exposures, then we have more light thrown upon them. We find them both in isolated and associated masses of great extent, and if we were able to trace them fully out in a seaward direction, they would seem to completely encircle the entire area of the serpentine and gabbro.

The "granulitic" portion can now no longer be regarded as confined to the east coast, as stated by Prof. Bonney, but is more or less extensive with nearly every portion of the entire coast-line. It forms the rocks all round the base of the Lizard Head.[1] It occurs at North Caerthillian, Holestrow, in great force at and near George's Cove, and also sparingly so at other localities.

The great extent of the dark hornblende schists exposed on the south coast is clearly connected with the "granulitic" at either extremity, and also to a small extent on the south where the schists approach the serpentine. We find a connection between the dark hornblende-schists and the typical "granulitic" on the east at a little cove south of the Lower Balk Serpentine Quarry, where we are able to trace the transition between both. On the west we are able to trace the same relations at Caerthillian, and at George's Cove the dark hornblende-schists or rocks are distinctly traceable by a gradual transition into the typical "granulitic," which occurs there in considerable force. On the east coast, as at Carnbarrow and Cadgwith, the typical hornblende-schists may be seen passing into the "granulitic" rocks, an excellent example being the fine section on the portion of the cliff between the Frying-pan and Cadgwith, which here clearly shows the very gradual transition of the one group into the other.

Altogether I think that the gist of the whole evidence is clearly to prove that both groups have had a common origin, and that the granulitic or granitic portion is not intrusive in the dioritic, or *vice versa*, but that both are part and parcel of the same magma. Subsequently these rocks may, and indeed have been deformed, and crushed up together, as at the Lizard Head, and other localities, but even here, with all the intricate confusion and alterations in their mineral aspects arising from this crushing and deforming process, the relations existing between these rocks show I think no indications of intrusion.

General McMahon[2] in his paper has certainly called attention to one instance of intrusion into the granulitic. He says, p. 533, "One of the intrusive diorites is well seen at Polbarrow, where a broad dyke of it cuts right across the 'granulitic' group between the ruined boat-house and the cliff. Down below veins of it may seen intruding into the granulitic."

[1] These rocks appear to me to have a decided claim to be ranked as portions of the "granulitic" group.

[2] Quart. Journ. Geol. Soc. vol. xlv.

This statement I must confess is rather fatal to my own views; but before forming a final opinion, I should like again to revisit this locality, as I cannot but think that the General may possibly have mis-read the section.

There is another example of the intrusion of a porphyritic diabase in the talco-micaceous group at Polpeor, first noted by Prof. Bonney,[1] and also referred to by General McMahon,[2] as follows: "The eruptive character of this rock is undoubted. At low-water during spring-tides, the reefs outside the island at Polpeor are exposed for about a mile from the shore. The porphyritic diorite may be seen in these reefs cutting right across the strike of the gneiss. Nearer land it is an intruder in the green schists, generally following their bedding, but constantly shifting from one horizon to another; whilst in the cliffs of the mainland it frequently shows itself at a still higher horizon among the micaceous and hornblendic-schists."

Prof. Bonney has certainly described this porphyritic diabase, or diorite as a true intrusive dyke, and the above quotation lends it all necessary support. When it was first pointed out to me by Mr. Howard Fox, I could not then and cannot yet separate it from the other hornblendic rocks or schists exposed there, as it seemed to me to form only a portion of these, but in a much less crushed condition. I afterwards had the pleasure of finding that Mr. Teall had previously expressed the same views in his notes for the "long excursion" of the Geologists' Association for 1887.

The relations as to the upper and lower position of these two groups is, I think, rather a difficult question. Prof. Bonney, who dealt with this matter on stratigraphical grounds, referred the "granulitic" to the uppermost position; but there seem to me good reasons for nearly reversing this conclusion, or at least modifying it to a considerable extent. There is the actual evidence of rocks with as good a claim as any to be regarded as "granulitic," holding the infra-position, which may be seen by boat in sailing round the Lizard Head, where this group is found supporting the hornblende-schists. This infra-position, however, I believe to be somewhat irregular, and to be regulated by certain circumstances, although on the whole I am inclined to regard the hornblende as the upper and outer margins of the same magma out of which both have been formed.

VI. Concluding Remarks.

I cannot conclude this paper without remarking that none of the views therein are held dogmatically, and expressing the hope that former observers will renew their attention, and fresh ones take up the investigation of this complicated, yet interesting area. The difficulties are great, among which is the origin of the banded structure, in the rocks herein dealt with, which in my next paper I shall try to explain on the grounds of segregation, arising from, or taking place during the cooling of the common magma out of which all these rocks seem to me to have been formed.

[1] Quart. Journ. Geol. Soc. vol. xxxix. p. 4.
[2] Quart. Journ. Geol. Soc. vol. xlv. p. 534.

NOTICES OF MEMOIRS.

I.—New Species of Fossil Sponges from the Siluro-Cambrian at Little Metis on the Lower St. Lawrence. By Sir J. William Dawson, LL.D., F.R.S. (Including Notes on the Specimens by Dr. G. J. Hinde.) Transactions of the Royal Society of Canada, vol. vii. section iv. 1889, pp. 31–55, pl. iii. and 27 figs.

In some black shales, belonging to the Quebec Group of Logan, exposed on the shores of the Lower St. Lawrence, Sir W. Dawson discovered some thin bands, largely filled with sponge-remains. In some instances the general form and outlines of the sponges have been preserved in a compressed condition, but more often the thin beds consist of a mass of spicules irregularly commingled together. In all cases the original siliceous structure of the spicules has disappeared, and they are now composed of pyrites. The sponges appear to belong almost exclusively to the Hexactinellidæ; the genus *Protospongia* is represented by six new species, *Cyathospongia* (*Cyathophycus*), Walcott, by one species, and *Hyalostelia* one species. A new genus, *Acanthodictya*, is proposed for cylindrical sponges with a dense fringe of spicular rays on the exterior, and some small oval sponges, in part at least apparently composed of simple acerate spicules, are placed in the new genus *Lasiothrix*. The specimens of *Protospongia* are more complete and better preserved than any hitherto known, and they are furnished with anchoring spicules, a structural feature not previously recognized in this genus. In one species, *P. tetranema*, the number of the anchoring rods is limited to four, and the author thinks they consisted of a single cruciform spicule of which the rays were bent upward and lengthened, forming a stalk for the sponge. It may be, however, that the rods are simple, and that the apparent union at their distal ends is not original, but produced in the fossilization. In another species, *P. coronata*, there is a distinct collar of curved spicules surrounding the cloacal aperture. Judging by the characters of the detached spicules many other additional species were probably present in these sponge-beds.

The only other recognizable fossils found in connection with these sponges are a small Brachiopod referred to *Obolella* (*Linnarssonia*) *pretiosa*, Billings, and some slender plant (?) remains which are named *Buthotrephis pergracilis*. The exact horizon of the black shales is not precisely determined, but Sir W. Dawson regards them as probably near the base of the Levis division, or equivalent to the English Arenig.

II.—*Thoracosaurus macrorhynchus*, Bl., aus der Tuffkreide von Maastricht. By Ernest Koken. Zeitschr. deutsch. geol. Gesell., 1888 (1889), pp. 754–773, pl. xxxii.

A fine Crocodilian cranium, evidently from the Maastricht Beds, now preserved in the Leiden Museum, forms the subject of this memoir. A detailed description and comparison proves the

fossil to be specifically identical with the so-called *Gavialis macrorhynchus*, made known by Gervais from the Upper Cretaceous of Mt. Aimé; and Dr. Koken further agrees with Dr. Leidy in referring this European type to the genus *Thoracosaurus*, which was originally founded upon a cranium from the Upper Cretaceous of New Jersey, U.S.A. The type-species of *Thoracosaurus* is said to possess antorbital vacuities, but these are not observed in the Maastricht fossil, and the author suggests that accidental fractures may have been mistaken for such in the New Jersey skull. Detailed comparisons are instituted, and the subject developes into an interesting treatise on the classification of the Crocodilia. Dr. Koken considers that *Thoracosaurus*, *Tomistoma*, and *Gavialis* are direct descendants of the Macrorhynchidæ, *Gavialis* being the most specialized form of this group, and having no intimate connection with the Teleosauridæ, which are regarded as a marine family that became extinct before the end of Mesozoic times. A long statement of anatomical facts leads to the conclusion that the Parasuchia are as nearly related to the Lizards as to the Crocodiles; and it is suggested that they may appropriately rank as equivalent to a group comprising all other so-called Crocodiles, an order Crocodiloidea being instituted, with the two suborders Parasuchia and Crocodilia. Agreeing with Lydekker, Dr. Koken considers that there is no satisfactory line of demarcation between the Mesosuchia and Eusuchia; but the arrangement adopted in the British Museum catalogue is characterized as unnatural and a purely stratigraphical classification. Amphicœlian and procœlian genera are now placed together in each of the three surviving families of Crocodilidæ, Alligatoridæ, and Macrorhynchidæ; the first arising with *Bernissartia*, the second with *Goniopholis*, and the third with *Pholidosaurus*, etc., this again subdividing into Tomistomatinæ and Gavialinæ. Incidentally it is pointed out that sclerotic plates are not peculiar to *Geosaurus*, as once stated, but that feeble ossifications occur also in the recent *Alligator*; and there is some evidence of *Cricosaurus* having possessed a dermal armour, thus differing in that respect from *Geosaurus*, as described. In a postscript, the author notes with satisfaction some recent observations of Mr. Hulke (Proc. Zool. Soc., 1888), which are in accordance with his own views. A. S. W.

III.—Première Note sur les Téléostéens du Bruxellien (Éocène moyen) de la Belgique. By Louis Dollo. Bull. Soc. Belge Géol., Paléont., Hydrol., vol iii. (1889), pp. 218–226.

M. DOLLO discusses the spines and other fragments of a Siluroid fish met with in the Bruxellian Beds of Belgium, already recorded under the name of *Silurus Egertoni*, Dixon. He concludes that these remains are specifically identical with the English Bracklesham fossils originally thus named, and agrees with the recent determination of the species as a member of the genus *Arius*.

IV.—"Ueber den Hautschild eines Rochen aus der Marinen Molasse." By Prof. A. Baltzer. Mitth. Naturf. Ges. Bern, April, 1889.

AN unusually large dermal tubercle of a Ray from the Molasse of Mägenwyl, Canton Aargau, is described and figured by Prof. Baltzer. The specimen measures about 0·05 in length, is of oval outline, and appears to consist of four broad, conical tubercles fused together. A microscopical section proves the Selachian nature of the fossil, and it seems to be related to the dermal tubercles already described under the names of *Acanthobatis* and *Dynatobatis*. The author does not suggest a generic or specific determination; but a postscript states that Dr. Jaekel regards the specimen as referable to the genus *Trygon*, and will shortly describe this with other evidence of the same fish from the Swiss Molasse.

V.—A Criticism of Dr. Croll's Theory of Alternate Glacial and Warm Periods in each Hemisphere, and of Interglacial Climates. By H. H. Howorth, M.P., F.S.A. (Memoirs Manchester Lit. and Phil. Soc. ser. 4, vol iii. 1890.)

BRIEFLY stated, the conclusions to be drawn from Dr. Croll's theory, are "that there has been throughout geological time an alternate glaciation of each hemisphere, ultimately caused by changes in the eccentricity of the earth's orbit, and directly engendered by the greater amount of warm water forced into each hemisphere by the alternately greater potency of the Trade winds North and South of the Equator." The author grants two of Dr. Croll's postulates, namely, that climate is largely dependent on the distribution of ocean currents, and that these are chiefly dependent on the winds; but he maintains that there is no evidence that the south-east trade winds are stronger than the north-east, the fact that they blow across the equator being accounted for by the situation of the parallel of greatest mean heat being to the north of that great circle. Here we have the largest area of land, or the "furnace" which causes the winds to blow across the equator; and thus Mr. Howorth argues that the circulation of the trade winds does not depend on special differences between the temperature of the equator and that of the north or south poles, at different periods.

There is no evidence to show that any great changes have taken place in the relative distribution of land and water since the Glacial epoch, whereby the parallel of greatest mean heat might have been shifted southwards; nor can Mr. Howorth find evidence to show extensive glaciation in the southern hemisphere, as compared with the northern.

The weakness of the evidence of Glacial periods in older geological eras is discussed by the author, and coming to the Glacial period itself, he points out the uncertainty of the evidence. "We have not yet (he says) found a key by which we can give a rational explanation of the true succession of so-called glacial deposits in two adjoining counties, much less in two larger geological areas." He

admits that mammoth's teeth and remains of other animals, contemporaries of man, have sometimes been found over and sometimes under Boulder-clay. This fact, no doubt, needs explanation, and can (he believes) be completely explained by an entirely different cause (as he proposes to show elsewhere). It certainly does not (in his opinion) support the theory of interglacial warm climates.

REVIEWS.

I.—Über die Gattung *Prisciturben*, Kunth. Von G. Lindström, Bihang till k. Svenska Vet.-Akad. Handlingar, Band 15, Afd. iv. No. 9 (1889), pp. 1–11, Taf. i., ii.

On the Genus *Prisciturben*, Kunth. By Professor G. Lindström, of Stockholm.

THE type forms of the genus *Prisciturben*, described by Kunth[1] as a Perforate Coral from the Silurian strata of Öland, have been unfortunately lost, and, owing to the death of this author, nothing but the description and figures remain by which the genus can be identified. Prof. Lindström thinks that the original specimens must have been derived from Gotland instead of Öland; for whilst nothing at all corresponding to the genus has been recognized from this island, there have been found in Gotland forms which agree in so many respects with Kunth's descriptions that there can be no doubt that they belong to the genus. The specimens in question are thin laminate expansions, with a concentrically rugose epitheca on the lower surface, and on the upper numerous small calices are irregularly grouped. The interspaces between the calices —described by Kunth as the cœnenchyma—are papillate and covered with delicate open channels radiating from various centres, and in this substance the calices are usually so immersed that their lateral walls are entirely concealed. The calices occur in all stages of growth; in the smallest, hardly 1 mm. in diameter, there is but a single septum developed on the lower side of the oblique calices; at a slightly older stage there are two additional septa, one on each side of the primary; these are followed by yet other two, similarly situated, and then a single septum appears on the upper side of the calice directly opposite the primary. In full-sized calices, which are not more than 4 mm. in diameter, there are from 30 to 36 septa, alternately large and small, and their outer margins are considerably thickened. The walls of the calices are faintly ribbed and sharply marked off from the cœnenchyma in which they are imbedded. The development of the septa in this Coral follows precisely the same course as that which Prof. Lindström has already noticed in many other Rugose Corals, as in *Goniophyllum*, *Cyathophyllum mitratum*, *Diphyphyllum*, sp., etc., but, curiously enough, this inequal development appears only to occur in species which in their earliest stages of growth are vermiform or tubular in shape, and attached by one side, whilst in species which are free and have a direct vertical

[1] Zeitschr. d. deutsch. Geol. Gesells. 1870, pp. 82—87, pl. 1, figs. 2*a*—2*b*.

growth, the septa are at first all of the same size and show a radial instead of a pinnate arrangement. Even in some specimens of *Prisciturben*, in which the calices have an upright mode of growth, the septa are fairly regularly radiate, without a pinnate or bilateral disposition.

Whilst the calices in *Prisciturben* exhibit all the characters of ordinary Rugose Corals, the substance in which they are imbedded, described by Kunth as cœnenchyma, shows in section a porous structure. This, on being submitted to Prof. H. A. Nicholson, was recognized by him as *Stromatopora typica*, v. Rosen, a characteristic Wenlock form occurring in England and Russia. It thus appears that *Prisciturben*, instead of being an abnormal Perforate Coral allied to the recent *Turbinaria*, really consists of two different organisms, a *Stromatopora* and a species of *Cyathophyllum*, which lived together, not always in harmony, as Lindström remarks, but rather in conflict, since in some specimens the *Stromatopora* grew at the expense of the Corals and nearly choked them, and in others the Corals were so numerous that there was little space left for the development of the *Stromatopora*. The interesting facts relating to these fossils are clearly shown in the figures which accompany Prof. Lindström's lucid descriptions. H.

II.—The Development of some Silurian Brachiopoda. By Charles E. Beecher and John M. Clarke. Forming vol. i. No. 1 of the Memoirs of the New York State Museum. pp. 95, 8 lithographed plates and 4 woodcuts. (Albany, 1889.)

WITH the completion of Davidson's great work on the Brachiopoda one might have been inclined to believe that very little more remained to be done with a group of shells upon which so much elaborate research had been expended, and with such splendid results. But we see in the volume before us how much of the life-history of the Brachiopoda yet remains to be written. Upon some of the living members of this group important treatises have from time to time appeared; notably that by Prof. E. S. Morse[1] on *Terebratulina*; another by Mr. W. K. Brooks[2] on *Glottidia*, and another by Dr. L. Joubin;[3] while M. Eugène Deslongchamps has treated of the development of the deltidium in the articulated Brachiopods. But as to the developmental history of fossil Brachiopods the field was quite open, and we are glad to see it occupied by such able and zealous workers as are the authors of the present volume. The results recorded by them could scarcely have been arrived at without the aid of rather exceptional circumstances; these were the following. A large collection of fossils[4]

[1] Mem. Boston Soc. Nat. Hist. vol. ii. "On the Early Stages of *Terebratulina septentrionalis*, pl. i. figs. 2, 3, 1869.

[2] Johns Hopkins University; Chesapeake Zoological Laboratory. "The Development of *Lingula* and the Systematic Position of the Brachiopoda," pl. i. and ii. 1879.

[3] Archiv. de Zool. Expérim. tom. iv. p. 161, 1886. A convenient abstract of this memoir has been given by Miss Agnes Crane in an appendix to the late Dr. Davidson's Monograph of Recent Brachiopoda; Trans. Linn. Soc. Lond., 2nd ser. Zool., vol. iv. pt iii. p. 236, Oct. 1888.

[4] We are told that the collection when received weighed no less than seven tons!

was made in the Niagara group at Waldron, Indiana, for the New York State Museum (Albany, N.Y.); the specimens were separated from the shales by washing and passing the material through sieves of different degrees of fineness, and by this means a vast number (about fifty thousand) of partly developed shells were obtained, most of which were less than five millimetres, and many not more than one millimetre in length. After rejecting imperfect and badly preserved specimens, more than fifteen thousand immature individuals still remained for examination. Besides the embryonic Brachiopoda, immature forms of Gasteropods and Crinoids were also found, but the material was not sufficiently promising to repay investigation. The number of species and varieties of Brachiopoda obtained from the Waldron Shales was forty-two, ascribed to twenty-four genera. Twenty-six of these species furnished data for the observation of developmental changes; of the rest no young shells were obtained. The genera represented were *Crania*, *Lingula*, *Pholidops*, *Orthis*, *Streptorhynchus*, *Strophomena*, *Strophodonta*, *Strophonella*, *Leptæna*, *Streptis*, *Chonetes*, *Eichwaldia*, *Pentamerus*, *Anastrophia*, *Rhynchonella*, *Rhynchotreta*, *Atrypa*, *Zygospira*, *Cœlospira*, *Retzia*, *Nucleospira*, *Meristella*, *Whitfieldia*, *Spirifer*. Of these the following species appear to have yielded the best results:—*Streptorhynchus subplanum*, Conrad; *Strophomena rhomboidalis*, Wilckens; *Strophonella striata*, Hall; *Meristella rectirostra*, Hall; *Spirifer crispus*, Hisinger; *S. crispus*, var. *simplex*, Hall; *S. radiatus*, Sowerby; and *S. bicostatus*, var. *petilus*, Hall.

The illustrations (plates i.—vii.) consist of enlargements of the embryonic shells, usually to the size of the adult, accompanied by figures of the full-grown shells, or, if the latter were too minute to show details of structure satisfactorily, these also were enlarged to the requisite size. Figures of special structures, such as the hinge, are also added. Plate viii. represents a series of specimens ranging from the very young to the adult shell; four species are figured, viz. *Orthis elegantula* (27 examples), *Streptorhynchus subplanum* (13 ex.), *Rhynchotreta cuneata* (20 ex.), *Retzia evax* (27 ex.). These show the character and completeness of the material serving as the basis of the work. The descriptions of the species are thus arranged: first, the developmental characters are taken up, and secondly, the specific characters of the mature form, and then those of the "incipient" form, and finally the developmental phases of the latter are described, as to their general shape, beaks, foramen, plications, etc. A useful summary of these changes is furnished at the end of the book, under the heading, Size and Contour; Valves; Beaks; Cardinal Area; Internal Apparatus; Surface Ornaments; Varieties and Abnormalities; Senility. Of these the Cardinal Area afforded by far the most important phylogenetic results, and accordingly the authors have devoted several pages to a discussion of the various phases it presents in different species. After describing the development of the ventral cardinal area, the authors observe that their results, "though derived from the species of a single fauna, must not be given too limited an application, for they involve nearly

every important family of Palæozoic articulate Brachiopods, and we may tentatively assume that, as a rule, the essential features of variation observed in any member of a genus will hold good of the other members. In regard to the development of the characters of the pedicle-passage, *i.e.* the deltidial plates and the foramen, there is good reason to regard the process as substantially identical in all the genera represented, making the necessary allowance for the peculiar variation seen in the Strophomenidæ, which may not, however, prove it an exception to the general statement."

After criticizing the observations of M. Eugène Deslongchamps in his "Note sur le développement du deltidium chez les brachiopodes articulés" (Bull. Soc. Géol. France, 2e sér. tom. xix. pp. 409—413, pl. ix. 1862), the authors sum up the results of their studies of the cardinal area in these words:—"It is not improbable that from an early form related to the genus *Orthis*, phylogenetic development tended in two main channels. One leading through *Strophomena*, *Scenidium*, *Orthisina*, *Leptæna*, *Chonetes*, *Productus*, and *Strophalosia*, and the other in the direction of *Rhynchonella*, *Spirifer*, *Atrypa*, *Retzia*, and *Terebratula*."

We congratulate Messrs. Beecher and Clarke upon the production of such a valuable instalment towards the complete developmental history of the Brachiopoda. A. H. F.

III.—The Vertebrate Animals of Leicestershire and Rutland. By Montagu Browne, F.Z.S. (Midland Educational Company, 1889.)

THE title of this work would scarcely lead the Palæontologist to expect any items relating to his province; and the ordinary naturalist will doubtless be surprised to find elephants, rhinoceroses, bisons, reindeer, and crocodiles indiscriminately mingled with the small "game" as elements of the Vertebrate Fauna of the counties under consideration. However, notwithstanding the misfortune (as we regard it) of confusing fragments of numerous successive faunas, as if they all belonged to one period, Mr. Browne's volume is a most welcome and important addition to the literature of the subject of which it treats. The book carries out a plan we would be glad to see followed by others specially conversant with the details of local faunas, living and extinct; and its accuracy as a work of reference is insured by the care with which the author has submitted all points outside his own immediate province to the judgment of several specialists. A systematic zoological arrangement is adopted throughout, commencing with the genus *Homo* and ending with *Petromyzon*; and the latest results in taxonomy and nomenclature are almost uniformly incorporated. The records of the bones and teeth of Mammalia met with in Pleistocene and other superficial deposits are chiefly based upon the collection in the Leicester Museum, of which the work gives a tolerably complete catalogue. In addition to evidence of man dating as far back as Neolithic times, there are remains of *Elephas primigenius*, *E. antiquus*, *Rhinoceros* (?) *leptorhinus*, *Equus caballus*, *Bison priscus*, *Bos*

primigenius, *Bos longifrons*, *Cervus elaphus*, *Capreolus capræa*, *Rangifer tarandus*, *Sus scrofa*, and the so-called *Sus palustris*. A word of warning is also added concerning Cetacean bones, which have often been introduced by man as ornamental gate-posts, and have sometimes been regarded as fossils—even ascribed in error to the mammoth. Ornithology, as may be expected, occupies the greater part of the volume, and comprises nothing of palæontological significance; but the final sections on Reptilia, Amphibia, and Pisces are concerned more with extinct than with living forms. The most important reptile-bearing stratum is the Lower Lias of Barrow-on-Soar, which has yielded *Ichthyosaurus communis*, *I. Conybearei*, *I. intermedius*, *I. tenuirostris*, *I. latifrons*, and *Plesiosaurus macrocephalus*, besides more doubtful species of the same genera. The fine example of *Ichthyosaurus* showing the pectoral fin will especially be remembered (Geological Magazine, 1889, p. 388). The Barrow quarries, moreover, yield fishes, among which are recorded *Mesodon liassicus*, *Pholidophorus Hastingsiæ*, *P. Stricklandi*, *Heterolepidotus serrulatus*, *Ptycholepis minor*, *Dapedius dorsalis*, *D. monilifer*, *D. orbis*, *D. striolatus*, *Cosmolepis Egertoni*, *Chondrosteus*, *Acrodus*, and *Hybodus*. *Belonorhynchus acutus* is also ascribed to the same locality, but the original specimen does not exhibit the ordinary physical characters of a Barrow fossil. To the Rhætic beds of Leicestershire are assigned *Ceratodus latissimus*, *Pholidophorus nitidus*, *Sargodon* (?) *tomicus*, *Gyrolepis Albertii*, *Saurichthys acuminatus*, *Acrodus minimus*, *Hybodus cloacinus*, *Hybodus minor*, and *Nemacanthus monilifer*. *Acrodus keuperinus* is represented by a spine and teeth from the Upper Keuper; *Strophodus magnus*, *Asteracanthus ornatissimus*, and *Hybodus crassus* occur in the Lower Oolites of Rutland; and there are several typical Coal-measure scales and teeth from the Ashby-de-la-Zouch Coal-field. Mr. Montagu Browne is still pursuing with success the palæontological aspect of the subject, as shown by the Addenda and more recent publications; and it may be hoped that in the next edition of the present work a considerable advance in our knowledge of the Vertebrate fossils of Leicestershire and Rutland will constitute one of its most striking features.

IV.—"Kopfstacheln von *Hybodus* und *Acrodus*, sog. *Ceratodus heteromorphus*, Ag." By Dr. Eberhard Fraas. Württ. Jahreshefte, 1889, pp. 233-240, pl. v. figs. 9–13.

THE heads of *Hybodus* and *Acrodus* discovered in the English Lias usually exhibit two laterally-placed pairs of hook-shaped spines, fixed upon broad, triradiate bases. These prove that the remarkable Triassic and Rhætic fossils commonly described as *Ceratodus heteromorphus* are not Dipnoan teeth, but the cephalic spines of Hybodont sharks. Dr. Fraas makes known the various forms of these spines met with in Würtemberg, giving some figures, and proposing a definite nomenclature. Some are theoretically assigned to various species of *Hybodus* and collectively named *Hybodouchus*; while others are similarly assumed to belong to *Acrodus*, and thus

termed *Acrodonchus*. It may be convenient for stratigraphical purposes to have provisional names for such fossils; but, as they possess no biological significance, we venture to think they are an unfortunate burden to scientific nomenclature. Moreover, in the present instance, the names proposed result from an imperfect acquaintance with previous researches. The term *Sphenonchus* was originally applied by Agassiz, not to the later Jurassic spines that prove to belong to *Asteracanthus*, but to the spines of *Hybodus* and *Acrodus* from the Lower Lias of Lyme Regis—a formation in which *Asteracanthus* has never been discovered. Again, the specimens in the British Museum show that there is no constant difference between the cephalic spines of *Hybodus* and *Acrodus*; and the true nature of these fossils is far from being a recent discovery, as reference to Mr. Charlesworth's paper of 1839, and Mr. Day's note of 1865, will show. If a provisional generic name of any kind be adopted, that of *Sphenonchus* thus has priority, while *Hybodonchus* and *Acrodonchus* are mere synonyms. A. S. W.

V.—An Elementary Text-Book of Geology: intended as an Introduction to the Study of the Rocks and their Contents. By W. Jerome Harrison, F.G.S. (London, Blackie & Co., 1889.) Small 8vo. pp. 200. Price 2*s.* 6*d.*

THIS little work may be recommended as giving a concise account of the leading geological facts, under the divisions of Descriptive Geology, Palæontology, and Historical or Stratigraphical Geology. It will be useful as an elementary class-book for students, and as an introduction to the larger manuals.

A new Russian Review.

VI.—"Revue des Sciences Naturelles." Société des Naturalistes, Université, St. Petersburg. (Annual subscription, 3 roubles 50 kopeks.)

ALTHOUGH Nīkītīn's admirable "Bibliothèque géologique de la Russie" enables geologists to obtain access to Russian literature more readily than can workers in other departments of natural science, nevertheless the publication of a monthly, in addition to an annual list, cannot fail to be welcome. Hence geologists will be interested in the success of the latest addition to Russian periodical literature—the Vyestnīk Estestvoznaniya, recently commenced by the St. Petersburg Society of Naturalists. This review will consist of original articles on various branches of natural science, with short French abstracts, and a bibliography, also in French, of Russian scientific literature; the first number, which has just been issued, including three geological articles, viz. a paper by Levinson-Lessing on "Some Chemical Types of Eruptive Rocks," a report by P. N. Venyukov on the Devonian beds of Mughodzhares, and a criticism by B. Polyenov on Michel Levy's "Structure et classification des roches eruptive."

The new journal is edited by the veteran physiologist F. V.

Ovsyannīkov, but it is evident from the list of promised contributors that geology will not be neglected. This list includes, in addition to those who have written in the first number, such geologists as Inostrantzev, Karpīnskiī, Amalītzkiī, Andrusov, Dokuchaev, Vernadskiī, and Nīkolskiī, while the mineralogists are represented by Eremyeev, Zemyatchenskiī, and Tīkhomīrov. J. W. G.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Annual General Meeting, February 21, 1890.—Dr. W. T. Blanford, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1889. In the former the Council had again to congratulate the Fellows upon the continued and apparently increasing prosperity of the Society, the affairs of which were in a very satisfactory condition. The number of Fellows elected during the year was 66, of whom 46 qualified before the end of the year, together with 15 previously elected Fellows, and these, with one Fellow readmitted, made a total accession of 62 Fellows during 1889. Deducting from this, however, 38 for losses by death, resignation, and removal, and for new Fellows compounding, the actual increase in the number of Contributing Fellows amounts to 24. The Balance-sheet for the year 1889 showed receipts to the amount of £2775 14*s.* 3*d.*, and a total expenditure of £2775 2*s.* 7*d.*, including a sum of £198 5*s.* 6*d.* expended in the purchase of stock. The balance in favour of the Society at 31st December was £249 4*s.* 1*d.* The Council's Report also referred to the Revision of the Bye-Laws completed in the spring of 1889, and in conclusion announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society. The Report of the Library and Museum Committee enumerated the additions made during the past year to the Society's Library and Collections, and referred briefly to the work done in the Museum, especially with regard to the glazing of the drawers in the Cabinets.

In handing the Wollaston Medal to Prof. J. W. Judd, F.R.S., for transmission to Prof. W. Crawford Williamson, F.R.S., the President addressed him as follows :—

Professor Judd,—The Council have awarded the Wollaston Medal for the present year to Prof. W. C. Williamson, in recognition of his researches in Palæontology, and especially of the series of important papers in which he has described the structure of the plants that have contributed to the formation of Coal. His investigations have added greatly to our knowledge of the Carboniferous flora, and have enabled us to form a much clearer idea of the plant-life in those far distant days of the Palæozoic era than was previously possible. Although Professor Williamson's attention has now for many years been especially devoted to the examination of fossil plants, he had, before his researches on ancient botany commenced, added many valuable details to our knowledge of the fossiliferous rocks of Yorkshire and Lancashire, and he had contributed greatly to the natural history of recent and fossil Foraminifera, whilst in a paper published more than 40 years ago, on some of the microscopical objects found in the mud of the Levant and other deposits, with remarks on the mode of formation

of calcareous and infusorial siliceous rocks, he anticipated many recent discoveries, both as to the part played by minute calcareous and siliceous organisms in rock-formation, and also as to the chemical and physical changes to which such organisms are subject during the conversion of soft deposits into hard stone.

In asking you to transmit this Medal to Professor Williamson, may I further beg that you will convey to him an expression of our wishes that he may continue his important studies for many years to come, and of our regret that his engagements have unadvoidably prevented our having the pleasure of his presence on this occasion.

Prof. Judd, in reply, read the following communication received by him from Prof. Williamson:—"I need scarcely say that I feel grateful for the honour done me in awarding me the Wollaston Medal; and I trust you will not deem me presumptuous when I express a hope that it has been won by conscientious work. Though the rich deposits of fossil plants discovered in the neighbourhood of Scarborough—my native town—drew my attention to palæobotany at an early age, it was only in 1851 that I commenced the study of their internal organization. I was led to this by a specimen for which I was indebted to our distinguished colleague Professor Prestwich, and which enabled me to interpret the anomalous objects known as *Sternbergia*. The success attending this exploration whetted the appetite; and from that time until now the organization of the Carboniferous plants has received my continuous attention. The difficulties impeding my work, which have been considerable, have chiefly arisen from one cause. Most of the Carboniferous plants belong to the Cryptogamic division of the Vegetable Kingdom, the only exceptions being some ancestral forms of the modern Cycads and Conifers. At the present day these Cryptogams are mainly low herbaceous plants. But forests and forest-trees were wanted in that primæval age, which want seems to have been inadequately supplied by the Gymnosperms just referred to. The want was met by uplifting the now lowly Cryptogams into Forest giants, and since the stems of these required some organization additional to that which living Cryptogams possess, to enable them to sustain their superstructures, they were strengthened for their work by the same exogenous growth as effects that end among modern forest trees. But that any Cryptogams should attain so high an organization was deemed by most botanists so improbable that their almost universal voice rejected my views upon the subject. But the truth has prevailed, and, happily for myself, I have been spared long enough to witness this end of my labours."

In conclusion, Prof. Williamson expressed his great indebtedness to Messrs. Cash, Aitkin, Butterworth, Nield, Earnshaw, Whitaker, Spencer, Binns, Wild, and Lomax, who have collected the valuable materials employed by him in his researches.

In presenting the Murchison Medal to Prof. E. Hull, F.R.S., the President addressed him as follows:—

Professor Hull,—In handing to you, who were one of Sir R. Murchison's colleagues on the Geological Survey of Great Britain and Ireland, the Medal founded by him, I shall not attempt to enumerate the many additions that you have made to our knowledge of the geology of the British Islands and to geological literature. Your contributions to the memoirs published by the Survey on various parts of England, and especially on parts of Gloucestershire, Oxfordshire, Cumberland, Cheshire, and Lancashire, are too well known to need recapitulation; and you have done good service to the cause of science by your treatment of one of the principal geological and economical problems presented to the Survey in your 'Coal-fields of Great Britain,' a work that has deservedly passed through several editions. You have aided greatly in the important series of investigations into the underground distribution of the productive Coal-measures when concealed by later unconformable deposits, and you have applied your extensive field-experience of British rocks to solve the difficult question of land-distribution in past epochs, and to the elucidation of the physical geography of the British Islands. For several years past, whilst holding your present post at the head of the Irish Survey, you have contributed in very many different parts of the country, and by the investigation of many distinct rock-formations, to our knowledge of Irish geology, and by your visit to Palestine you have been able to throw much light on the geological structure of the Holy Land.

Prof Hull, in reply, said:—I appreciate very highly the honour which you and the Council have conferred in awarding to me the Murchison Medal. The gratification I feel is enhanced by the circumstance that this distinction is associated with the name and memory of the founder, who was to me a wise and considerate chief as well as a personal friend.

You have been pleased to refer to my official work on the Geological Survey of the United Kingdom, as well as to that of a more personal nature. It has been my lot to serve under four successive chiefs, namely, De la Beche, Murchison, Ramsay, and Dr. Geikie, whose names will ever be associated with the early history and progress of geological science; and I may truly say that from each and all I received that encouragement and support which is essential to the hearty fulfilment of the duties of a public servant; and I am glad to have this opportunity of saying that in bringing the Geological Survey of Ireland to its completion I have been associated with colleagues in this work who have combined an earnest desire to fulfil their duties to the public service with no small amount of enthusiasm in carrying on scientific investigation. In view of my pending retirement from this department of the public service, I am somewhat consoled by the hope that, in consequence, I may be enabled, at no distant day, to take a more active part in the work of this great Society than has hitherto been possible. In conclusion, I have only to express my thanks to you, Mr. President, for the kind words in which you have communicated to me the award of the Council; these will be an incentive to further effort in the cause of geological investigation.

The President then presented the Lyell Medal to Prof. T. Rupert Jones, F.R.S., and addressed him as follows:—

Professor Rupert Jones,—There is unusual pleasure in presenting one of the chief awards in the gift of the Council to a geologist who has been so long and so honourably associated with the Geological Society as yourself, and the appropriateness of the award is not decreased by the circumstance that your official connexion with the Society commenced when the great geologist who founded this medal was President. Since that time, now forty years ago, you have written much on various fossil organisms, but especially on Entomostraca and Foraminifera, and in many cases, and especially amongst the bivalve crustaceans of the older rocks, it is largely to your researches that we are indebted for our present knowledge of the forms. You have also devoted much time and attention to the geology of South Africa, and to bringing together the scattered information that we possess concerning the geology of that interesting region.

In placing the Lyell Medal in your hands I can only add that I think the Council have carried out the intentions of Sir Charles Lyell, and that they are justified in believing that, in his words, "the Medallist has deserved well of the Science."

Prof. T. Rupert Jones, in reply, said:—Acknowledging, with respecttul thanks, the unexpected honour with which the Council, on the part of the Society, has favoured me, I beg to state that, in following the study of those branches of geological science to which opportunity and other circumstances have led me to give my best attention, I cannot claim to have been so successful, or so useful, or deserving of such honourable recognition as the Council, in their kindness towards an old worker, seem to have considered me to be.

Thanks to a natural disposition to study both living and fossil organisms, and to look with confidence for signs of the great Divine laws governing the earth and all its belongings, my humble part has been, as far as possible, that of a true "Minister et Interpres Naturæ."

No great discovery, however, nor signal success in elucidating the problems offered for our study, in the organic and the inorganic world, has been attained by me. Persistent and, may be, an industrious search among geological facts for their causes and history, and among fossils, especially microzoa, for evidence of their exact relationships, to the end that our knowledge of these things should be more perfect and more useful, has occupied much of my intellectual life.

How far the Foraminifera, Ostracoda, and Phyllopoda have been already, or will in the future be useful palæontological guides to the geologist cannot be noticed here.

In all that I have done my work has been my pleasure, and I can claim no reward for it; and in all that has been good I have to acknowledge warmly the co-operative help given by W. K. Parker, J. W. Kirkby, H. B. and G. S. Brady, Henry Woodward, and C. D. Sherborn; and in just now completing the Supplemental Monograph of the Cretaceous Entomostraca I have had the kind aid of G. J. Hinde.

This Medal, Sir, bequeathed by my old and revered friend Sir Charles Lyell, and the other Awards given so graciously this day by the Council and yourself, on behalf of the Geological Society, bear striking and pleasant testimony to the fact that the good deeds of great and good men live after them.

The President next presented the Balance of the Wollaston Fund to Mr. W. A. E. Ussher, F.G.S., and said :—

Mr. Ussher,—In connexion with the Geological Survey of the counties of Somerset, Devon, and Cornwall, it has been your province to examine many of the rocks exposed, and in addition to your official work you have contributed several useful accounts of the Palæozoic, Triassic, and Pleistocene deposits to the Journal of this Society and to other geological publications. In recognition of the good work done by you the Council have authorized me to present you with the balance of the Wollaston Donation Fund.

Mr. Ussher, in reply, said :—I thank the Council for the recognition of work this Award implies, and you, Sir, for your allusions to it. Whatever results I may have obtained in the discharge of my ordinary duties on the Geological Survey are not deserving of reward. The construction of maps may be faithfully performed without obtaining results of moment in the furtherance of geological knowledge; official requirements are so engrossing and imperative as to oblige those who, like myself, desire to acquire as competent an acquaintance as possible with the strata on which they are employed, to supplement, by private work, the information acquired in public duty. The results obtained by private investigation, whensoever they contribute to the advancement of our common science, are in themselves rewards.

The result of my twenty years' experience in geological mapping is this :—the acquirement of patience and the entire subordination of theoretical considerations, which should be the outcome of a careful study, collation and comparison of details, and not the working hypothesis to weld them into system during or before the progress of the work.

This principle I have had to keep in view in Pleistocene work, in dealing with a variable and disturbed series of Triassic rocks, and to a still greater extent in dealing with fossiliferous rocks such as the Lias, Oolites, Carboniferous, and Devonian. I have learned the extreme importance of Palæontology in investigating disturbed Palæozoic areas, where it appears to me that the evidences of fossils and of stratigraphy should be taken together, and without subordinating the one as a mere adjunct to the other.

In presenting the Balance of the Murchison Geological Fund to Mr. E. Wethered, F.G.S., the President addressed him as follows :—

Mr. Wethered,—The remainder of the Murchison Donation Fund has been awarded to you by the Council of this Society on account of the researches you have undertaken into the microscopic structure of sedimentary rocks, and to aid you in prosecuting further inquiries. The results of your examination of the insoluble residues obtained from the Carboniferous Limestone, and of the remarkable minute tubular forms (apparently organic) from various limestones, that you have ascribed to *Girvanella*, are of great interest, and have furnished an important contribution to our knowledge of the manner in which Palæozoic and Mesozoic limestones have been formed.

Mr. Wethered, in reply, said :—I desire to express to the Council my thanks for the honour done me in making me the recipient of the Murchison Fund for the year. This kind consideration will greatly encourage me in pursuing that branch of geological research which I have marked out as one of the objects of my life. To have done work which merits the acknowledgment of this Society—the first in the world—is one of the greatest satisfactions a geologist can enjoy.

You have referred to my work on the microscopical examination of limestones, and I should like to say that in this there is a most important field open for investigation. If those who have the opportunity of examining the oldest limestones would do so through the microscope, with due regard in preparing the slides to the optical properties of the rock, my belief is that our knowledge of the life which existed at that early period of the earth's history would be considerably advanced.

I again return my thanks for the honour done me.

The President then presented the Balance of the Lyell Geological Fund to Mr. C. Davies Sherborn, F.G.S., and said :—

Mr. Davies Sherborn,—There is no branch of scientific work at the present day that confers a greater benefit on geologists in general than the recording of geological and palæontological literature. Owing to various causes, the mass of published

matter increases yearly; and as it is impossible for any one to read all that appears, a heavy debt is due to those who undertake the arrangement of a key to the various publications. In Palæontology this is even of greater importance than in Geology. In your recently published 'Bibliography of the Foraminifera,' and in the Catalogue of 'British Fossil Vertebrata,' published in conjunction with Mr. Smith Woodward, you have contributed to that important object the establishment of a general palæontological list with full references; whilst in the assistance given to the 'Geological Record' you have done good service to the science for the advancement of which this Society exists. As a mark of the value attached by the Council to the completion of a general index to palæontological writings, and as an assistance in the compilation of any portion of the work that you may undertake, I have much pleasure in presenting to you the Balance of the Lyell Donation Fund.

Mr. Sherborn, in reply, said:—I must ask you, Sir, to express my thanks to the Council for the distinction they have shown me in awarding me the Proceeds of the Lyell Fund. I feel great diffidence in accepting such award, my work having extended over but few years. I have endeavoured to make that work as perfect as possible, and hope to devote my future time to bibliographic research. I wish to thank Prof. Rupert Jones and Mr. Topley for first assistance in my work, and I assure you, Sir, I shall always labour to make my work more perfect.

In presenting to Mr. W. Jerome Harrison, F.G.S., a grant from the Proceeds of the Barlow-Jameson Fund, the President addressed him as follows:—

Mr. Harrison,—In awarding to you a grant from the Barlow-Jameson Fund, the Council recognize the value of your endeavours to spread a knowledge of Geology by the compilation and publication of hand-books to the Geology of the Counties in England and Wales. They also appreciate your geological researches in the Midland Counties, and trust that the award now made may be of use to you in the prosecution of future efforts to extend geological knowledge.

Mr. Harrison, in reply, said:—In thanking the Council for the honour they have conferred upon me, I can only say that their award was as unexpected as it was welcome. The daily tasks of a necessarily busy life have left me but little time for original research, and I have done—not what I *would*, but what I *could*. This recognition of my labours, and the kind words with which you have accompanied it, will spur me on to increased endeavours in those studies which the Geological Society was established to promote.

The President then read his Anniversary Address, in which, after giving obituary notices of several Fellows, Foreign Members, and Foreign Correspondents deceased since the last Annual Meeting, including the Venerable Archdeacon Philpot (who was the senior Fellow of the Society, having joined it in 1821), Dr. H. von Dechen (the oldest Foreign Member, elected in 1827), Mr. Robert Damon, Mr. J. F. LaTrobe Bateman, Mr. H. W. Bristow, Dr. John Percy, the Rev. J. E. Tenison Woods, Mr. Thomas Hawkins, Prof. F. A. von Quenstedt, Prof. Bellardi, Dr. Leo Lesquereux, and Dr. M. Neumayr, he referred briefly to the condition of the Society during the past twelve months and to a few works on palæontological subjects published in the same period. He also mentioned the finding of Coal *in situ* in a boring at Shakspere's Cliff, and then proceeded with the main subject of his Address, namely, the question of the Permanence of Continents and Ocean-basins. After reviewing the evidence derived from the rocks of oceanic islands, and the absence of deep-sea deposits in continental strata of various ages, he proceeded to the points connected with the geographical distribution of animals and plants, and gave reasons for believing that Sclater's zoological regions, founded on Passerine birds, were inapplicable to other groups of animals or plants, and that any evidence of con-

tinental permanence based on such regions was worthless. He also showed that both elevations and depressions exceeding 1000 fathoms had taken place in Tertiary times, and gave an account of the biological and geological facts in support of a former union between several lands now isolated, and especially between Africa and India *via* Madagascar, and between Africa and South America. From these and other considerations it was concluded that the theory of the permanence of ocean-basins, though probable, was not proved, and was certainly untenable to the extent to which it was accepted by some authors.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year :—*President*: A. Geikie, LL.D., F.R.S. *Vice-Presidents*: Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; W. H. Hudleston, Esq., M.A., F.R.S.; J. W. Hulke, Esq., F.R.S. *Secretaries*: H. Hicks, M.D., F.R.S.; J. E. Marr, Esq., M.A. *Foreign Secretary*: Sir Warington W. Smyth, M.A., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S. *Council*: Prof. J. F. Blake, M.A.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; James Carter, Esq.; John Evans, D.C.L., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; A. Geikie, LL.D., F.R.S.; Prof. A. H. Green, M.A., F.R.S.; A. Harker, Esq., M.A.; H. Hicks, M.D., F.R.S.; Rev. Edwin Hill M.A.; W. H. Hudleston, Esq., M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; Major-Gen. C. A. McMahon; J. E. Marr, Esq., M.A.; H. W. Monckton, Esq.; E. T. Newton, Esq.; F. W. Rudler, Esq.; Sir Warington W. Smyth, M.A., F.R.S.; W. Topley, Esq., F.R.S.; Rev. G. F. Whidborne, M.A.; Prof. T. Wiltshire, M.A., F.L.S.; H. Woodward, LL.D., F.R.S.

II.—February 26, 1890.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communication was read:—

"On the Relation of the Westleton Beds or 'Pebbly Sands' of Suffolk to those of Norfolk, and on their Extension inland, with some Observations on the Period of the Final Elevation and Denudation of the Weald and of the Thames Valley."—Part III. On a Southern Drift in the Valley of the Thames, with Observations on the Final Elevation and Initial Subaerial Denudation of the Weald, and on the Genesis of the Thames." By Prof. Joseph Prestwich, D.C.L., F.R.S., etc.

In this third part of his paper the author gave a description of the character of the Southern Drift, showing how it differs from the Westleton Beds in the nature of its included pebbles, which consist of flints from the Chalk with a large proportion of *chert* and *ragstone* from the Lower Greensand, while there is a total absence of the Triassic pebbles and Jurassic débris characterizing the Northern Drift. He traced the drift through Kent, Surrey, Berkshire, and Hampshire, and described its mode of occurrence.

Another preglacial gravel was then discussed under the title of the Brentwood group, and its age was admitted to be doubtful.

The author then entered into an inquiry as to the early physiographical conditions of the Wealden area, and gave reasons for supposing that a hill-range of some importance was formed in the Pliocene period after the deposition of the Diestian beds. From the denudation of this ridge, he supposes that the material was furnished for the formation of the Southern Drift, which may have been deposited partly as detrital fans at the northern base of the range.

The relation of the Southern Drift to the Westleton Shingle and

other preglacial gravels was considered, and the Westleton Beds were referred to a period subsequent to that of the formation of the Southern Drift.

The influence of the meeting of the earlier Wealden axis with that of the folding which produced the escarpments of central England was discussed, and it was suggested that the result would be the genesis of the Thames-valley and river.

The following summary gives the results of the author's inquiry as developed in the other parts of the paper. He holds:—

1. That the Westleton shingle ranges from Suffolk to Oxfordshire and Berkshire, rising gradually from sea-level to 600 feet.

2. That the lower Tertiary strata were coextensive with this shingle.

3. That the upraising of the Westleton sea-floor, with its shingle, preceded the advance of the glacial deposits, and that the latter became discordant to the former when traced westward, occupying valleys formed after the rise of the Westleton Beds.

4. That the Tertiary strata and Westleton Beds on the north border of the Chalk-basin were continuous until the insetting of the Glacial period, when they were broken through by denuding agencies.

5. That none of the present valleys on the north of the Thames Tertiary-basin date back beyond the Preglacial period.

6. That the same date may be assigned to the Chalk-, and probably to the Oolite-escarpments.

7. That in the Thames-basin, besides the Northern Drift, there is a Southern Drift derived from the Lower Greensand of the Wealden area, and from the Chalk and Tertiary strata formerly extending partly over it.

8. That during the Diestian period the Weald was probably partly or wholly submerged, and that between this and the insetting of the Glacial period, the Wealden area and the Boulonnais underwent upheaval, resulting in the formation of an anticlinal range from 2000 to 3000 feet high.

9. That from the slopes of this range the materials of the Southern Drift were derived, and spread over what is now the south side of the Thames basin.

10. That this denudation commenced at the time of the Red Crag, and went on uninterruptedly through successive geological stages.

11. That consequently, though the Southern Drift preceded the Westleton shingle, the two must at one time have proceeded synchronously.

12. That the valley-system of the Wealden area dates from Pliocene times,—the initial direction of the transverse valleys from Preglacial times.—and of the longitudinal valleys from Glacial times.

13. That the Thames basin results from the elevation of the Weald and the flexures of the Chalk and Oolites of the Midland counties, and dates from a period subsequent to the Westleton Beds.

14. That the genesis of the Lower Thames similarly dates from early Pleistocene times, whilst its connection with its upper tributaries and the Isis, which possibly flowed previously north-eastward, took place at a rather later period.

III.—March 12, 1890.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read :—

1. "On a Deep Channel of Drift in the Valley of the Cam, Essex." By W. Whitaker, Esq., B.A., F.R.S., F.G.S.

In Scotland and in Northern England long and deep channels filled with Drift have been noticed, but not in Southern England.

For some years one deep well-section has been known which showed a most unexpected thickness of Glacial Drift in the higher part of the valley of the Cam, where that Drift occurs mostly on the higher grounds and is of no very great thickness. Lately, further evidence has come to hand, showing that the occurrence in question is not confined to one spot, but extends for some miles. The beds found are for the most part loamy or clayey.

At the head of the valley various wells at Quendon and Rickling show irregularities in the thickness of the Drift, the Chalk coming to or near the surface in some places, whilst it is nearly 100 feet below it sometimes.

Further north, at Newport, we have the greatest thickness of Drift hitherto recorded in the South of England, and then without reaching the base. At one spot a well reached Chalk at 75 feet; whilst about 150 feet off that rock crops out, showing a slope of the Chalk-surface of 1 in 2. In the most interesting of all the wells, after boring to the depth of 340 feet, the work was abandoned without reaching the Chalk, the Drift in this case reaching to a depth of about 140 feet below the level of the sea, though the place is far inland. The Chalk crops out about 1000 feet eastward, and at but little lower level, so that there is a fall of about 1 in 3 over a long distance.

At and near Wenden the abrupt way in which Drift comes on against Chalk has been seen in open sections. Two wells have shown a thickness of 210 and 296 feet of Drift respectively; and as the Chalk comes to the surface, at a level certainly not lower, only 140 yards from the latter, the Chalk-surface must have a slope of 1 in less than $1\frac{1}{2}$, and this surface must rise again on the other side, as the Chalk again crops out. The Drift here reaches to a depth of 60 or 70 feet below the sea-level.

At Littlebury, in the centre of the village, a boring 218 feet deep has not pierced through the Drift, which reaches to 60 feet below the sea-level. As in a well only 60 yards west and slightly higher, the Chalk was touched at 6 feet, there must here be a fall of the Chalk-surface of about 1·2 in 1. Eastward too, on the other side of the valley, the Chalk rises to the surface.

The places that have been mentioned range over a distance of 6 miles. How much further the Drift-channel may go is not known, neither can we say to what steepness the slope of the underground Chalk-surface may reach; the slopes given in each case are the lowest possible.

The author thinks that the channel has been formed by erosion rather than by disturbance or dissolution of the Chalk.

2. "On the Monian and Basal Cambrian Rocks of Shropshire." By Prof. J. F. Blake, M.A., F.G.S.

In a previous paper the author had suggested that the Longmynd rocks were referable to the Upper Monian. He now finds that they are divisible into two groups, of which the lower only can be thus referred.

This lower group is divisible into five parts:—1. Dark Shales; 2. Banded Series; 3. Purple Slates; 4. Hard Greywackés; 5. Pale Slates and Grits. These are shown to have a real dip to the west, and not to be thrown into any folds. It is in these only that fossils have been found. The lowest dark shales are not basal rocks, nor derived from the eastern volcanic series.

The junction of the upper group, which represents the true Cambrian, is unconformable, as shown by detailed stratigraphy. It consists of three members, the middle one being slates which die out northwards. There is neither synclinal nor anticlinal fold, but a regular sequence and dip; and pale slates follow on the west. The base is brought into connexion with each division of the lower series except No. 2. The conglomerates contain:—1. Quartz; 2. Rhyolites; 3. Gneissic rocks; 4. Slates like those of the underlying group. The supposed Archæan masses on the western border are non-existent, being intrusive and transgressive igneous rocks.

The volcanic group on the east is not bounded by the main fault, the dark shales lying to the east of that fault. Evidence is given that the volcanic rocks have been protruded through these shales, which they have altered. The Eurite of the Wrekin is of later date, and the only possible older rocks are the Rushton Schists and the fragments of schistose rocks on Primrose Hill.

At several places patches of red grit and conglomerate are seen on the Volcanic hills: these are referred to the Cambrian, and their connexion also with earlier conglomerates forming part of the Volcanic series is suggested. The Cambrian quartzite is later than all these, but may be synchronous with the upper part of the western Grits.

The Volcanic rocks are not, therefore, Middle Monian, as formerly supposed, but represent the interval between Monian and Cambrian. If classed with either, the author inclines rather to place them with the Cambrian, in spite of the unconformity of the quartzite. He regards them as probably the equivalents of the Bangor Series, and possibly of the St. David's Volcanic Group. If this classification be adopted, then the Monian system will be entirely separated from the Pebidian, and be established on distinct and independent observations.

3. "On a Crocodilian Jaw from the Oxford Clay of Peterborough." By R. Lydekker, Esq., B.A., F.G.S., etc.

The symphysis of the mandible of a Thecodont Reptile obtained by Mr. Leeds from the Oxford Clay near Peterborough was described by the author, and reasons were given for referring it to the Crocodilia rather than to the Sauropterygia. An imperfect skull found by Mr. Leeds in the same formation at Peterborough appears to belong

to the same form as the mandible, and shows that the latter cannot be referred to *Machimosaurus*.

After reviewing the whole of the evidence, the author concluded that he was dealing with a Crocodilian allied to *Metriorhynchus*, but forming the type of a new genus, to which he gave the name of *Suchodus*, adding the specific name of *durobrivensis*.

4. "On two new Species of Labyrinthodonts." By R. Lydekker, Esq., B.A., F.G.S., etc.

The right ramus of the lower jaw of a Labyrinthodont, from the Lower Carboniferous of Gilmerton, near Edinburgh, is regarded as referable to the Permian genus *Macromerum*, and it is proposed to describe it as *M. scoticum*.

Another mandible from the Karoo system of South Africa is referred to the American Permian genus *Eryops* under the name of *E. Oweni*.

CORRESPONDENCE.

THE CRYSTALLINE SCHISTS OF THE LEPONTINE ALPS.

SIR,—To the abstract of my paper on "The Crystalline Schists and their Relation to the Mesozoic Rocks in the Lepontine Alps," read before the Geological Society on January 22nd, and reprinted in the last Number of this MAGAZINE, has been appended a long letter written by Dr. Heim in anticipatory criticism, which was read during the discussion. As the printing of that letter *in extenso* appears to me to be a feature even more novel in your MAGAZINE than it is in the Abstracts of the Geological Society, I request space for the following remarks:—

1. I must leave to casuists more experienced than myself the task of reconciling certain parts of that letter (as to what has been said by Swiss geologists) with the paper, presented by Dr. Heim to the International Geological Congress in 1888. After comparing them, I can only put the old question, "What then does Dr. Heim mean?"

2. The Carboniferous rocks of the Alps were only incidentally mentioned in my paper. But I know something of these also, and shall be surprised if it can be proved that any sedimentary rocks of this age have been converted into true crystalline schists, or that the "Calamite-like trunk from Guttanen" (which I have seen) occurs in a gneiss.

3. In regard to the "crystalline schistose rocks" of Mesozoic age, in which it is stated that Belemnites occur with staurolites, garnets, etc.,—rocks which are now said not to be true crystalline schists—I have only to remark that the whole aim of my paper was to show that the rocks with garnet, staurolite, etc., were true crystalline schists, that they were totally distinct from the schistose rocks with fossils, that the former were below not above the (Triassic) rauchwacké, in which some of their members actually occur as fragments, that the Belemnite-bearing rocks have only a superficial

resemblance to the schists with garnet and staurolite, and that the authigenous minerals in them are neither garnet nor staurolite, but some impure hydrons silicates. Dr. Heim's letter merely asserts the contrary to my contentions, without adducing any fresh evidence.

T. G. Bonney.

THE CULM-MEASURES AT BUDE, NORTH CORNWALL.

Sir,—I have read with much interest the paper by Major-General McMahon on the rocks at Bude. During one of two summer visits to Tintagel I made a short stay at Bude, and saw the extremely contorted strata so well described in the paper referred to. Like the author of that paper, I was desirous of seeing what amount of metamorphism had resulted from so much pressure and dislocation, but expecting to pay a longer visit I took away only two specimens. These were taken from two layers, a few inches apart, of a very sharp fold exposed in a cove a little way south of Bude Haven,—I think it was "Efford Ditch." One of the layers was darker in colour, much softer, and more laminated than the other.

If any conclusions may be drawn from so limited a stock of material (and macroscopically, at least, my specimens appeared fairly representative of many of the rocks in this and other cliffs of the district), the rocks of Bude are entitled to complain that they have been made to appear as being less appreciative of, and as making less return for, the large amount of force expended on them than is really the case.

The microscope shows the general structure and composition of my specimens to be exactly as described by Major-General McMahon; but a close study of very thin portions of slides, under high powers, shows a good deal more, especially in the harder of the two layers.

In among the unaltered original clastic material may be seen a considerable amount of rutile, perfectly distinct from any bits of that mineral which may have come from older rocks. There are large numbers of acicular crystals of it, vividly polarizing, as well as countless minute dark rods, so well shown in many slates, etc. It is also present in grains and granular aggregates, and in plates, some of them of relatively large size. The total amount of it varies much, even in slides from the same small piece, but it is always considerable, and in one slide from the harder layer of rock it is particularly abundant. This slide also shows a good many long crystals of tourmaline (quite distinct from the clastic grains of that mineral) and a good deal of secondary sericitic mica, some of it rich in rutile crystals. Indeed, parts of this slide at once remind one of some of the sericite-phyllites of the Tintagel rocks, in which the rutile occurs in just the same manner; and comparisons of the two leave little doubt that some at least of the Bude strata have made a good start towards the metamorphism which is so intense at Tintagel.

Of course it may be that my two specimens are exceptional, and that Major-General McMahon did not chance on these or similar layers.

But in any case, even though these specimens show that *all* the Bude rocks are not without distinct evidence of metamorphic action, it is still true that the effect produced is not in anything like the proportion we might expect, from the stresses endured by these beds.

I am not able to follow some of the reflections which Major-General McMahon bases on the supposed total absence of alteration at Bude.

Hallock's experiments (as quoted), and still more Hallock's conclusion from them, seem to be beside the mark. It is not generally supposed that pressure is able to liquefy rocks,—quite the reverse in fact,—and there does not seem to be any justification for saying that "consequently" no chemical or mineralogical changes are to be expected.

Again, Spring's experiments are admitted to have proved that pressure can produce chemical combinations and re-arrangements; and nothing that was done by "Professor Spring's pestle and mortar" would be lacking in the intermixture of minute particles of minerals in the fine silt of which these Bude rocks and similar strata are largely composed. There is no call here for rocks to be "crushed and ground to pieces by irresistible geological disturbances." All the crushing and grinding has been done in the gentlest and quietest way, and the resulting material has but to lie and await the pressure.

Whether pressure, with or without movement, is in itself sufficient to intensely metamorphose sedimentary rocks, is another question.

And, if it *is* sufficient, there is still much room for inquiry and speculation as to why it acts so comparatively feebly at one place and so very intensely a few miles away, when, so far as can be judged from the rocks, the feebler metamorphism has by no means corresponded to feebler stresses.

NEWCASTLE-ON-TYNE,
March 10th, 1890.

W. MAYNARD HUTCHINGS.

CONTORTION AND METAMORPHISM.

SIR,—General McMahon's "Notes on the Culm-measures at Bude" in the March Number of this MAGAZINE (p. 106) form a welcome contribution to the petrology of the district, and have a particular interest as indicating the probable derivation of the strata in question from the destruction of granitic rocks. The fact that the Culm-measures are much contorted without having experienced any appreciable mineralogical changes seems, however, to have only a limited bearing on the general question of metamorphism by pressure.

Adopting the familiar treatment employed by Thomson and Tait, we may usefully resolve any system of strains into (i) a uniform voluminal compression and (ii) certain shears. The term shear is here used in its strict sense, viz. deformation apart from change of volume, and it is evident that the varying amounts of shearing from point to point within the mass express themselves completely in the contortion of the rocks affected, faulting being regarded for this

purpose as a particular case of contortion. In like manner the correlated stresses resolve into (i) a uniform pressure and (ii) certain shearing stresses. The energy set free consists of two parts; (i) that due to compression, measured by the product of the uniform pressure into the relative compression, and (ii) that due to shearing, measured by the products of the shearing stresses into the amounts of the corresponding shears. The total energy thus set free, except in so far as it is lost by conduction of heat, must be absorbed in the production of mineralogical changes. Rocks are known to be very bad conductors of heat, but the amount of energy lost in this way must vary with circumstances, time being an important factor.

Again, viewing the strains and stresses in a rock-mass with reference to the external forces that produce them, it is essential to notice that the voluminal compression and uniform pressure depend upon the *sum* of the forces acting in different directions (*e.g.* vertically and horizontally) while the shears and shearing stresses depend upon the *differences* of those forces. We may, for example, picture a mass of rocks subjected to a lateral thrust and to the weight of overlying rocks. If the mass be situated at no great depth, the latter force may be very much less than the former, and considerable shearing may be produced if the material be not a very rigid one, or if the thrust be of long duration; for shearing is, within limits, proportional to the time. The pressure and the total energy set free may or may not be very great, and under a comparatively small cover of rocks much of the energy must be lost by conduction. It is thus easy to imagine conditions under which any amount of contortion may be produced without any metamorphism of the rocks so affected.

If the same lateral thrust operate upon a rock-mass at a greater depth beneath the surface, it will be more nearly balanced by the weight of the cover, and so the compression and pressure will be greater, but the shears and shearing stresses less. The total energy set free will be greater, and there will be less loss by conduction. We may thus have metamorphism produced with or without contortion.

In the case of rocks at a depth, too, the time-element must be important. The rigidity of the mass being there materially diminished —this, at least, is generally admitted—there must be a tendency to propagate pressure uniformly, as in a liquid. If this property hold good to any extent, shearing stresses cannot be set up unless the disturbing forces increase comparatively suddenly. However this may be, it appears that the contortion of rocks cannot afford an accurate measure of the forces which have produced it, and that contortion and dynamo-metamorphism, though due to the same ultimate cause, are by no means necessarily associated in the same place. One or the other phenomenon may occur alone, or both together, in accordance with complex conditions, such as the depth of the cover, the rigidity of the rocks affected, and the slowness or rapidity of development of the disturbing forces.

General McMahon apparently calls in question the experimental

researches of M. Spring and others on the physical and chemical changes produced by the action of high pressures. It seems rather rather late in the day to take this position, but the subject is too wide to be discussed here. The Belgian physicist, too, is well able to defend himself: witness his reply to the American critic cited by General McMahon.

ALFRED HARKER.

ST. JOHN'S COLLEGE, CAMBRIDGE.

COCCOSTEUS DECIPIENS.

SIR,—In a very important paper on the structure of *Coccosteus decipiens*, Ag., Dr. Traquair has recently remarked (Ann. & Mag. Nat. Hist. [6] vol. v. p. 125) that he suspects I have mistaken the lateral margin of the interlateral plate for a pectoral spine in my description of *Coccosteus*, and he feels justified in asserting that, if such a pectoral swimming organ does really exist in *C. Bickensis*, that species cannot be referred to *Coccosteus*, in which no such appendage is present.

In reply, I must repeat that there occurs a hollow, triangular, bony spine, filled with calc spar, quite distinct from the other plates. Apart from this spine, *C. Bickensis* agrees so well with undoubted species of *Coccosteus*, that I am inclined to regard Dr. Traquair's statement cited above as not yet beyond question; and although a similar pectoral organ has not yet been recognized in Scottish specimens, it is quite likely it may still be found. I am all the more confirmed in this opinion since, according to Dr. Traquair, the sclerotic ring appears to exist only in *one* specimen from Gamrie in the Edinburgh Museum, while it is rather common in my German specimens. The pectoral spine is much more rarely seen in my fossils than the sclerotic ring, and I am thus not astonished that it should hitherto have escaped observation in the Scottish examples of *Coccosteus*. Finally, I would add that the spine in *C. Bickensis* attained a length of 55mm. (fig. 12 of my paper on Placoderms), but the end is wanting, the impression of it being retained on the rock. It is therefore not shorter, but much longer than in the restoration of *Brachydeirus inflatus*.

I may add that my specimens are exposed in the Royal Geological Museum here at Göttingen, and may be examined by any one interested in the subject.

A. VON KOENEN.

GÖTTINGEN, *March 12th*, 1890.

TIDAL ACTION.

SIR,—As tidal action has been called in of late in your pages to assist if possible in solving the riddle of the Triassic sandstones and conglomerates, it may be well to point out one line of evidence which seems to have been overlooked by the supporters of the tidal theory, *i.e.* the zoological.

Mr. Mellard Reade writes as follows in the Philosophical Magazine, vol. xxv. p. 342:—"Although it is on the littoral margins and the shallow seas opening into the oceans that the resistless force of the tides is most obvious," etc., etc.[1]

[1] See Mr. Mellard-Reade's Article in this Number, *supra*, p. 157.—ED. GEOL. MAG.

The English Channel is an excellent test case. It is shallow and opens full into the Atlantic Ocean. It lies east and west, and accordingly offers no impediment to the free play of the currents generated by the tidal wave which runs from east to west.

If unchecked tidal currents are anywhere resistless, they should be so here. Do these tidal currents disturb the gravel, or sand or even the mud on the Channel bottom? The marine fauna of the district answers this question with an emphatic negative.

It is generally admitted that very few molluscs can exist in an area of shifting sand, and the denizens of the Channel bottom are not of the number. They are, it is true, wonderfully provided with diverse defences against currents of a peculiar nature, viz. the alternating currents set up by waves; but even these must not be too violent, or the molluscs will perish by the million, as indeed they often do from this cause alone.

Geologists interested in the question of denudation and distribution by tides and waves will be familiar with Delesse's "Lithologie du Fond des Mers," and the admirable atlas accompanying that volume. If they will turn to Map 2, they will note that the area of the English Channel most frequented by shells extends from west of the Land's End to Ushant, and up the centre of the Channel to a point off Exmouth; with another large sandy area of shells west of Ushant. These are precisely the localities where we might expect the tidal currents to make a clean sweep of the Channel bottom, but nothing of the sort occurs. The presence of this Molluscan fauna in these very exposed localities is good proof that unchecked tidal currents sweeping over a fairly level sea-bottom are incapable by their own unassisted efforts of raising the sand; a glance at the map will show that they cannot even wash away the mud.

This being my special craze, and having noted observations and experiments thereon for many years, on shore and afloat, I could fortify my position at such length as would insure this letter finding a place in the editorial waste-paper basket, so I refrain.

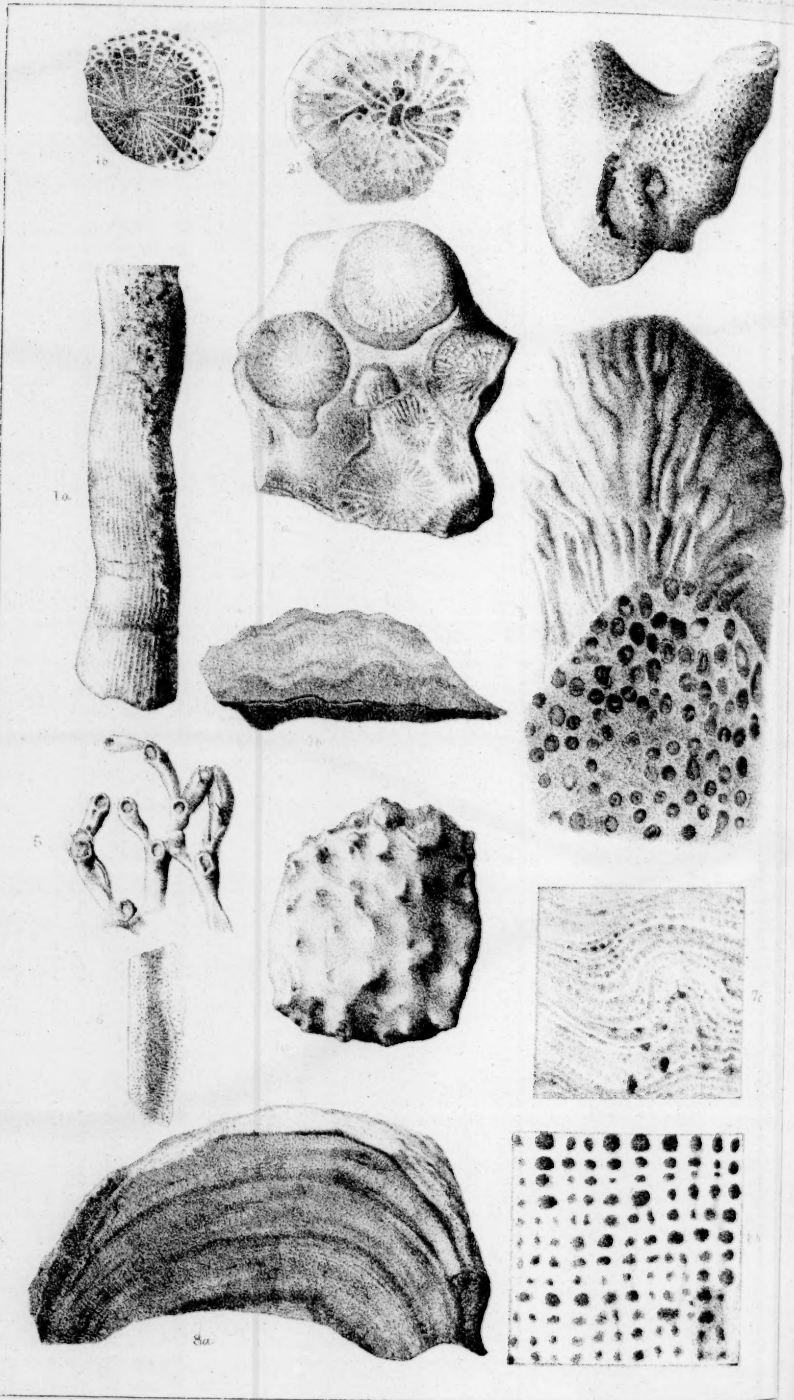
One word in conclusion—would Mr. Mellard Reade give his reasons for believing that waves ever cause surface particles in deep water to move in "an ellipse, not very different from one having the longer axis vertical"? I have heard this stated by a lecturer, who drew a vertical ellipse on the blackboard like the long eye of a bodkin; but I have never seen the statement in print except in Mr. Mellard Reade's paper above referred to (p. 338).

Southwood, Torquay. Arthur R. Hunt, F.L.S.

MISCELLANEOUS.

The Discovery of Coal at Shakespere's Cliff.—In February last Prof. W. Boyd Dawkins, F.R.S., announced that Coal had been reached in the experimental boring near Dover. A seam of coal of good bituminous character was reached at 1180 feet from the surface, 3 feet 6 inches in thickness, with a 4 inch parting of shale and sandstone in the middle.[1] The boring is to be continued for another 1000 feet, if necessary, to ascertain whether other beds of workable coal exist at a lower level.

[1] An oil-shale is also mentioned.



G. M. Woodward del. et lith.

West, Newman imp.

West Australian Fossils

2. Corals and Polyzoa. By George J. Hinde, Ph.D., F.G.S.

Genus Amplexus, Sowerby.

Amplexus pustulosus, Hudleston.

1883. *Amplexus pustulosus*, Hudleston, Q.J.G.S. vol. xxxix. p. 591, pl. xviii. figs. 1*a*–1*c*.

There are several compressed and crushed fragments of this species, which agree in every respect with the forms figured by Mr. Hudleston, save that they have none of the surface spines or nodes, from which the species derives its name. These processes, however, are not essential to the species, since they are not present on some of the figured type examples, which, through the kindness of Mr. Hudleston, I have had an opportunity of examining. The specimens, when uncompressed, are from 25 to 30 mm. in diameter. There are about 40 septa; at the summit of the calice they are 2 mm. apart, from centre to centre; lower down from 1·5 to 1·75 mm. In some instances in the lower portion of the coral, the septa become so thickened by sclerenchyma as to be laterally in contact. The outer surface, when unweathered, merely exhibits annulations of growth and fine epithecal striæ; the weathered examples show vertical lines and furrows, which are the exposed exterior margins of the septa.

Distribution.—Carboniferous Limestone, Gascoyne River.

Genus Cyathophyllum, Goldfuss.

Cyathophyllum virgatum, Hinde, sp.n. Plate VIII. Figs. 1*a*, 1*b*.

Corals simple (?), subcylindrical, elongated, straight or curved. About 56 septa, half of which are long and reach nearly to the centre of the calice; the others only reach from one-third to one-half that distance; there are about five septa in three millimètres. The septa are thick near their parietal margins, but somewhat rapidly diminish in size, and for the greater part of their length are very thin. They are connected by very stout dissepiments, which form a well-marked exterior zone to the calice. The wall is apparently formed by the lateral extension of the septa. The septa are apparently bilaminate, but the median line is not distinctly shown in sections. The outer surface of the coral is smooth or with faintly-marked longitudinal ridges, which correspond with the interspaces between the septa. When the surface is weathered, as in the specimen figured (Fig. 1*a*), the exterior margins of the septa appear as vertical lines connected by the dissepiments.

There are several imperfect examples of this species; the longest measures 70 mm. by about 11 in diameter. One specimen is partly covered by *Aulopora repens*. The specimens are now all simple, but it is not impossible that they may originally have formed fasciculate, compound colonies, like those of *Cyathophyllum cæspitosum*, Goldf. Though the character of the septa in this and the next species corresponds with that of the typical forms of the genus, it is doubtful whether the wall in these Australian forms is structurally similar to the Eifelian types; it is relatively much thicker than those with which I have been enabled to compare it.

Distribution.—Devonian (?). Opposite Mount Krauss, Kimberley District. Also from the Gascoyne River.

Cyathophyllum depressum, Hinde, sp.n. Plate VIII. Figs. 2*a*, 2*b*.

Corallum compound, consisting of several subcylindrical corallites growing from a simple base: the individuals are for the most part free; when full-grown, about 17 mm. in diameter. There are about 58 septa, alternately large and small; some of the larger extend to the centre of the calice, and slightly curve round. The parietal margins of the septa are very thick, and there is an outer zone of thick dissepiments. The wall and septa of the same character as in the preceding species, from which it is distinguished by its mode of growth, the larger size of the corallites, and the stouter septa.

Distribution.—Devonian? Opposite Mount Krauss, Kimberley District. Another fragmentary specimen, partly incrusted by *Stromatoporella Eifeliensis*, Nicholson, is labelled from the Gascoyne River.

Genus Plerophyllum,[1] Hinde, gen. nov.

Syn. (?) *Pentaphyllum*,[2] De Koninck, 1872, preoccupied in 1821 for a genus of Coleoptera.

Generic Characters.—Simple, conical, turbinate or subcylindrical corals, with deep calices. There are usually five prominently developed septa (in some species only four), which reach nearly to the centre of the calice; the other septa are subequal. In the species with five prominent septa, the cardinal septum is small and is bounded on either side by a large septum, and the remaining three large septa represent the counter and alar septa. Where only four prominent septa are developed, one of them constitutes the cardinal septum. Both large and small septa exhibit a distinct opaque median lamina, which begins within the substance of the wall, and is inclosed by successive layers of stereoplasm, so that in the lower portion of the coral the septa are laterally in contact, and the interlocular and central areas are filled up with solid tissue. The wall of the coral is thick, and consists apparently of the coalesced parietal margins of the septa with an outer epithecal layer. The outer surface exhibits either shallow annulations of growth with fine concentric striæ, or longitudinal rugæ, or, more rarely, spinous projections.

I had at first placed the Australian Corals on which this genus is based in *Pentaphyllum*, De Kon., but it appears that this term had been previously employed, and as, moreover, some doubt[3] rested on the characters of the Belgian types, it seemed preferable to prepare

[1] Πλήρης, full, in allusion to the way in which the corallum is filled up by stereoplasm.

[2] Nouvelles Recherches sur les Animaux fossiles du terrain Carbonifère de la Belgique, p. 58.

[3] For example, the main characteristic of *Pentaphyllum* is stated to be the possession of five prominent septa, but in the figure of the unique typical species, *P. armatum* (*l.c.* pl. iv. fig. 8*a*.), *six* are clearly shown; whilst in the only specimen of the other species included by De Koninck in this genus, *P. caryophylliacum*, there are but four prominent septa (*l.c.* pl. iv. fig. 9).

a new diagnosis. The genus nearest allied to *Plerophyllum* is *Anisophyllum*,[1] Edwards and Haime, founded on a small coral from the Devonian of Tennessee, in which only three prominent septa are developed, and these, according to Prof. Nicholson,[2] are the cardinal and alar septa. It is, besides, uncertain, whether the basal portion of the corallum in this genus is infilled by stereoplasm.

PLEROPHYLLUM AUSTRALE, Hinde, sp.n. Plate VIIIa. Figs. 1*a*–1*f*.

Small conical, straight or curved corals, about 30 mm. in height, and from 10 to 14 mm. in diameter at the summit. The number of septa is usually 26; of these 5 are large and prominently developed, and 21 are smaller and subequal; sometimes there are two or three additional smaller septa. The cardinal septum is small, with a prominent septum on either side (Pl. VIIIa. Fig. 1*d*). Normally, this cardinal septum is on the dorsal or convex side of the coral; but in some instances the orientation differs, and this small septum between two larger is situated laterally (Figs. 1*e*, 1*f*). The counter-septum is large, and between it and the large alar septa there are on either side four or five smaller septa. The septa are but slightly developed at the summit margins of the calice; lower down the prominent septa extend to about two-thirds of the distance to the centre of the calice; their interior free margins are distinctly tumid or bulbous (Fig. 1*d*), and by successive additional layers of stereoplasm, they become still more so in the lower portions of the coral, until they meet and fill up the central area completely. The smaller septa vary considerably in size and in relative proportions to the larger. Within the calice they are often slender and extend only about one-third the distance to the centre (Fig. 1*d*); at a lower level in other specimens they are relatively much larger (Fig. 1*e*), and their free margins become bulbous by layers of stereoplasm, which finally unites them laterally, and they can then only be separately distinguished by their dense median lamellæ. The corals are not uniformly filled up at the same level with the stereoplasm, and possibly the spaces left vacant may be of the nature of fossulæ (Fig. 1*f*). The median lamellæ of the septa are sometimes curved and wavy; in the Figures (1*d*, *e*, *f*) they are represented by lighter lines as they appear by reflected light; in thin sections by transmitted light this central substance is opaque and dense.

The exterior surface of this species when well preserved is smooth, with delicate concentric epithecal striæ (Fig. 1*b*), but when weathered the median laminæ of the septa are shown as deeply impressed longitudinal lines or furrows (Figs. 1, 1*c*).

This species appears to be not uncommon, but the forms are all imperfect, and the calices are infilled with a hard matrix, so that the interior structures can only be studied from sections.

Distribution.—Carboniferous, Gascoyne River; Irwin River, Little Champion Bay, Victoria District.

[1] British Fossil Corals, Pal. Soc. 1850, p. lxvi. Polyp. foss. des terr. pal. p. 351, pl. i. figs. 2, 2*a*.

[2] Manual of Pal. 3rd ed. vol. i. p. 296.

Pleurophyllum sulcatum, Hinde, sp.n. Plate VIIIa. Figs. 2, 2*a*.

Corallum curved, approximately subcylindrical, showing in the upper portion repeated renewals of growth. The only specimen, which is imperfect, is 40 mm. in height and 11 mm. in diameter. There are in all 28 septa, of which 4 are prominently developed and the others are subequal. The cardinal or dorsal septum is large; between it and the alar septa there are on one side 7, and on the other 8 smaller septa, whilst the large counter-septum has between it and the alar septa 4 smaller on one side and 5 on the other. The septa are about 1 mm. apart; they are of precisely the same characters as in *P. australe*, and they are similarly inclosed and consolidated by stereoplasm, so that in a transverse section of the lower portion of the coral the individual septa can only be recognized by their median lamellæ (Fig. 2*a*).

The outer surface in this species has well-marked longitudinal ridges and furrows about half a millimètre in width, which appear to be quite independent of the septa.

There is only a single example of this species in the collection. From *P. australe* it is readily distinguished by not having more than four prominent septa and by the different characters of the outer surface.

Distribution.—Carboniferous, Irwin River, Little Champion Bay, Victoria District.

Genus Pachypora, Lindström.

Pachypora tumida, Hinde, sp.n. Pl. VIII. Fig. 3.

Corallum branching; branches subcylindrical, tumid; ranging from 10 to 13 mm. in diameter. Corallites nearly circular in section; walls moderately thick, both in the central portions of the branches as well as near the surface; calices elongate-oval, subcircular or rhomboidal, about 1 mm. in diameter, moderately oblique to the surface. No septa or septal spines shown; tabulæ apparently few and complete; mural pores rare.

There is but one fragment of this species in the collection; it is about 40 mm. in length. The weathered upper surface shows the calices in fairly good preservation. From its surface aspect, this form would perhaps be regarded as belonging rather to *Alveolites* than to *Pachypora*; but judging from the thickened walls of the tubes, it may more properly be included in this latter genus. The calices however look much more like *Alveolites* than those of *P. cervicornis*, De Blainv., and they are larger and more oblique than in *P. meridionalis*, Nich. & Eth. jun. (Ann. & Mag. Nat. Hist. ser. 5, vol. iv. (1879) p. 280). On the other hand, the calices are less oblique and less regular than in *Alveolites* (*Cladopora*) *robusta*, Rominger (Fossil Corals, Geol. Surv. Michigan, p. 54, pl. 32, figs. 1, 2), which is regarded by Nicholson, though not with absolute certainty, as referable to *Alveolites*. As regards its mode of growth, *P. tumida* stands on the boundary-line between *Pachypora* and *Alveolites*.

Distribution.—Devonian? Opposite Mount Krauss, Kimberley District.

Genus SYRINGOPORA, Goldfuss.

SYRINGOPORA RETICULATA, Goldfuss, var. PATULA, var. nov. Pl. VIII. Fig. 4.

1826–33. *Syringopora reticulata*, Goldfuss, Petref. Germ. vol. i. p. 76, pl. xxv. fig. 8.
1852. *Syringopora reticulata*, Edwards and Haime, Brit. Foss. Corals, p. 162, pl. xlvi. figs. 1, 1*a*.
1872. *Syringopora reticulata*, De Koninck, Nouv. Rech. sur. les Anim. foss. pt. i. p. 123, pl. xi. figs. 7, 7*b*.
1879. *Syringopora reticulata*, Nicholson, Tabulate Corals, p. 215, fig. 30; and pl. x. fig. 5.
1880–1. *Syringopora reticulata*, Nich., Proc. Roy. Soc. Edinburgh, p. 225, fig. 3.

Corallum forming low bushy masses of cylindrical, flexuous radiating corallites, ranging in diameter from 1·6 to 2·15 mm. The largest specimen examined is 50 mm. in height by 110 mm. wide. The distance between the corallites varies from ·5 to 2 mm.; they are connected at irregular intervals, more by the interosculation of proximate corallites than by horizontal processes between them. The corallites also increase by frequent lateral buds given off from the stems, the young stems having the same general direction of growth as the parents.

The corallites have thick uniform walls about ·25 mm. in thickness; the septal spines appear to be irregularly developed, and reduced to small conical projections from the inner surface of the wall; in some transverse sections not more than three or four are visible, whilst in others there are five or six in about one-fourth the circumference of the corallite. The infundibuliform tabulæ are of the usual character, and there is no special infilling of sclerenchyma within the corallites.

I have ventured to place these specimens as a variety of *S. reticulata*, since, though the corallites are of about the same dimensions, they appear to increase more rapidly by lateral budding, and thus to diverge more in their mode of growth, and the connecting processes between them, if not altogether absent, are so reduced as to be scarcely distinguishable. The specimens are now imbedded in nodular masses of compact limestone, and their minute structural characters are very clearly shown in thin sections. The corallite walls consist, as pointed out by Prof. H. A. Nicholson (Proc. Roy. Soc. Edinburgh, 1880–1, p. 225), of two layers, an exterior, which is formed of compact sclerenchyma either granular or radiately fibrous, and an inner layer of concentrically arranged wavy fibres, which are interlaced together. In these Australian forms the exterior layer of the walls is of the same tint as the inner, and can scarcely be distinguished from it. It appears, however, to be present, and can be recognized in transverse sections as a thin outer zone of a granular character, whilst the inner layer is markedly of wavy fibres; there is, however, no definite line between the two layers. It is worthy of note that this wall-layer of wavy interlacing fibres seems to be very characteristic of *Syringopora* and its allies. In *S. Maclurei*, Billings, from the Devonian of Canada, the walls, which are very thick, appear to be wholly of this wavy structure, whilst in *Rœmeria minor*, Schlüter, from the Devonian of the Eifel, there is a well-marked exterior layer of radiating fibres, within which is

the layer of wavy concentric fibres, thus corresponding in character to *S. reticulata*.

Distribution.—Gascoyne River. Not known whether Devonian or Carboniferous.

Genus Aulopora, Goldfuss.

Aulopora repens, Knorr and Walch. Pl. VIII. Fig. 5.

1775. *Milleporites repens*, Knorr & Walch, Recueil, etc., tome iii. p. 157, pl. vi. fig. 1.
1826–33. *Aulopora serpens*, Goldfuss, Petref. Germ. vol. i. p. 82, pl. xxix. figs. 1*a*.
1879. *Aulopora repens*, Nich., & Eth., jun., Ann. & Mag. Nat. Hist. ser. 5. vol. iv. p. 282.

There is a single example of this species growing on the surface of *Cyathophyllum virgatum*, which, as far as its outward characters are concerned, cannot be distinguished from the type forms of the species from the Eifel. The corallites range from 2·5 to 4·5 mm. in length, and from 1 to 1·25 mm. in thickness. The oval or elliptical apertures are between ·75 mm. and 1 mm. in width.

Distribution.—Devonian? Rough Range, Mount Krauss, Kimberley District. This form has been already recorded by Messrs. Nicholson and Etheridge from the Devonian Limestone of Arthur's Creek, North Queensland.

ANNELIDA.

Genus Spirorbis, Daudin.

Spirorbis omphalodes, Goldfuss, sp.

1826–33. *Serpula omphalodes*, Goldf. Petref. Germ. pl. lxvii. fig. 3.

There are several specimens of a small *Spirorbis*, attached to the surface of *Cyathophyllum virgatum*, which appear to belong to the above species. They are about 2 mm. in diameter and ·75 mm. in height, the upper edge of the outer whorl is obtusely angular or rounded, surface apparently smooth.

Distribution.—Devonian? Gascoyne River.

POLYZOA.

Genus Polypora, M'Coy.

Polypora australis, Hinde, sp.n. Pl. VIIIa. Figs. 3, 3*a*.

Polyzoary flabellate, dimensions uncertain. Branches nearly straight, radiating from the base and bifurcating at intervals of about 6 mm.; they are from 1 to 1·2 mm. in width, flattened, with the dissepiments on the same plane. The fenestrules are elongate oval, about 2 mm. in length by ·6 mm. wide, and about 2 mm. apart longitudinally. The cells are regularly arranged in quincuncial rows; there are five cells in an oblique row; the rows are continued across the dissepiments. The cell-apertures are circular, not apparently elevated, small, about ·15 mm. in diameter, and separated from each other by about their own diameters. The branches are about ·5 mm. in thickness. The reverse side of the frond is concealed by the matrix.

This species appears to be nearest allied to an Indian form,

referred by De Koninck to *P. fastuosus* (Q.J.G.S. vol. xix. 1863, p. 5, pl. i. fig. 4); but it differs in the narrower fenestrules; the dissepiments are also larger and carry cells. Only a single fragmentary specimen known.

Distribution.—Carboniferous, Gascoyne River.

Genus Hexagonella, Waagen and Wentzel.

Hexagonella dendroidea, Hudleston, sp. Plate VIII. Fig. 6 and VIIIa. Figs. 5–5*d*.

1883. *Evactinopora dendroidea*, Hudleston, Quart. Journ. Geol. Soc. vol. xxxix. p. 594, pl. 23, figs. 3*a*—3*d*.
1886. *Hexagonella dendroidea*, Waagen and Wentzel, Mem. Geol. Surv. India, ser. xiii. p. 913.
1889. *Evactinopora dendroidea*, R. Etheridge, jun., Proc. Linn. Soc. New South Wales, vol. iv. p. 207.

The examples of this species appear to be more abundant than those of any other fossil from the Carboniferous Limestone strata of the Gascoyne River, and the numerous specimens in the collection afford an excellent opportunity of ascertaining its minute characters. Since this form was described by Mr. Hudleston in 1883, several other species of the same genus have been recorded by Waagen and Wentzel from the Carboniferous strata of the Punjab, and these authors have proposed the new genus *Hexagonella* for their reception. As will be shown later on, the characters of this genus are so similar to those of *Fistulipora*, M'Coy, that it may be doubted whether it should be considered as more than a subgenus; but at the same time the species included in it possess in common some slight structural features, which make it desirable to place them in a distinct group, and I propose therefore to retain Waagen and Wentzel's name. Considerable interest attaches to this genus, since, according to these authors, it exhibits a mode of increase by so-called cœnenchymal gemmation, which, in their view, indicates distinctly that this and similar allied forms should be considered as Corals rather than Polyzoa. This evidence in favour of the cœlenterate nature of these organisms has been quoted by Prof. Nicholson,[1] and by the late Prof. Neumayr,[2] as strong proof of the correctness of the view that they are Corals. As the result of a careful study of numerous sections of the Australian species, which there can be no doubt is closely similar to the Punjab forms, I can find no indication of this alleged cœnenchymal gemmation, but, on the contrary, a mode of growth from a basal lamina which is strongly characteristic of Polyzoa, and as in other structural features these forms resemble Polyzoa. I accept this view of their character, which, it may be said is that originally held by Mr. Hudleston.

Hexagonella dendroidea occurs as solid, straight or curved stems or branches, ranging from 30 to 80 mm. in length, from 10 to 22 mm. in width, and from 5 to 15 mm. in thickness. The specimens are all fragmentary, the stems are usually compressed, sometimes nearly cylindrical, of an even width and thickness, except where

[1] Manual of Palæontology, third edition, vol. i. p. 352.
[2] Die Stämme des Thierreichs, p. 324.

they dichotomize (Plate VIIIa. Fig. 5). They are of a hard, greyish limestone, completely weathered out of the matrix; but the tubular cells and interstitial vesicles are partly infilled with chalcedony, and in part with calcite.

The outer surface of the branches is divided into irregular polygonal areas by raised lines or ridges, sometimes scarcely visible without a lens, at others elevated above the surface so as to form margins to depressed areas (Figs. 5, 5*c*). These ridges are given off from the angles of a zig-zag line, having a generally vertical direction on the narrow sides of the branch. The ridges pass indifferently across the cell areas and the maculæ, but they frequently meet in the centre of these latter. In weathered specimens these ridges are not recognizable, and they are not often visible in sections, unless tangential, where they appear as rows of bead-like dots, with dark centres and lighter borders, not unlike the spines in Monticuliporoids.

The surface of the branches is dotted over with maculæ; these are oval or subcircular spaces free from cells (Fig. 5); without definite boundaries, from 2 to 3 mm. in width, and from 5 to 8 mm. apart, from centre to centre. The maculæ are usually even with the general surface, though sometimes slightly below it. The general surface of the branches, both of the maculæ and of the areas between the cell-mouths, is, when well preserved, covered with microscopically minute blunted tubercles which appear to be solid and imperforate (Fig. 5*c*). As a rule, however, the branches are now smooth and imperforate.

The centre of the branches has a median lamina extending from end to end, from which the cells are given off. This axial lamina is double in character; in thin sections it appears as a dark line with a layer of lighter material on either side of it, the whole being about ·05 mm. in thickness. It seems to be quite imperforate (Figs. 5*a*, *b*).

The cells (= autopores) in this species are relatively long tubes, circular, elliptical, or oval in section (Fig. 5*d*); they commence their growth on the central lamina as conical tubes, semi-elliptical in section; in the first stage they are recumbent on the lamina for a distance of about ·75 mm., they then curve abruptly outwards and extend directly to the surface, to which they open nearly at right angles (Fig. 5*b*). The cell-walls are distinct from the interstitial substance, imperforate, of an even thickness throughout their length, not thickened near the surface, and in their upper portions apparently of concentric fibres. At irregular intervals, from ·25 to ·75 mm. apart, they are partitioned by complete tabulæ (Fig. 5*b*); but they are not infilled in any way with sclerenchyma. Measured in transverse section, the cells are from ·2 to ·25 mm. in diameter, but a few of the larger ones on the borders of the maculæ are ·37 mm. wide. The cell-walls are from ·03 to ·05 mm. in thickness; in some instances they exhibit a decided thickening or lip at one side; this is of a more opaque character than the rest of the wall (Fig. 5*c*). Beyond this thickening, there are no projections of the lip-margins within the cell or distinct trifoliation of the cell itself, as in many

species of *Fistulipora*, and also in *Hexagonella lævigata*, Waagen and Wentzel (Pal. Indica, ser. 13, pl. 115, fig. 5).

On the surface of the branches, the cells are arranged in rows which radiate from the maculæ as centres. The cells in the rows are somewhat less than half a millimètre from centre to centre, and about the same distance between the rows. The cell-apertures are slightly oblique to the surface, and there is a distinct elevated lip, in some cases semilunate or crescentic in form (Fig. 5*c*). The cells near the maculæ are larger, more oblique, and with thicker lips than others.

As a rule, the cell-apertures are open, but in many instances the cells are partially or entirely closed by calcareous lids, placed just within the lip of the cell (Fig. 5*c*). These lids are flat or slightly convex, and usually incomplete, a central or sub-central space remaining open. In other cases this aperture is wholly closed by a minute central papilla. Occasionally the lid is evenly convex, and projects beyond the rim of the cell-wall. These lids appear to be distinct from the tabulæ in the lower portion of the cell; they are thicker; convex, instead of flat or concave; and they are frequently incomplete.

The spaces between the cells, where they radiate upwards to the surface from the axial lamina, are occupied by interstitial tissue or cancelli (= mesopores) (Fig. 5*b*). This is of two kinds; one, occupying principally the central portion of the branches, is mainly vesicular, and formed by convex vesicles arranged sometimes in linear series, sometimes irregularly overlapping and dovetailing into each other (Fig. 5*b*). The peripheral portions of the branches on the other hand mainly consist of a solid imperforate tissue deposited in thin concentric zones. Occasionally, however, there is a layer of vesicles within the exterior solid zone, and sometimes a thin solid band intercalated in the central vesicular area. The solid substance does not, however, seem to be a mere infilling of the vesicles; but it is of a distinct character replacing the vesicles. On polished surfaces, and in sections viewed by reflected light, this substance can be seen to consist of delicate rods or spines vertically arranged and imbedded in a lighter material, and it appears that the minute tubercles with which the surface is covered are the upward extensions of these bodies. In transparent, transverse sections, this solid tissue has an indistinct cloudy appearance, due to innumerable, opaque dots—the section of the rods—in a lighter substance (Fig. 5*d*). The thickened portion or lips of the cells likewise consists of these solid spines or rods.

No mention is made of this solid interstitial tissue in the Punjab species of *Hexagonella*, but it is shown in the figures of *H. ramosa* (Pal. Indica, ser. 13, pl. 107, fig. 3*c*). Similar tissue is likewise present in certain specimens of *Fistulipora incrustans*, which have been described by Mr. John Young, F.G.S. (Ann. & Mag. Nat. Hist. April, 1888, p. 245), and in *Goniocladia cellulifera*, R. Eth., jun. (Geol. Mag. Dec. I. Vol. X. p. 433, Pl. XV.)

The general question as to the relation of *Hexagonella* or *Fistulipora* to Polyzoa or Corals is too wide to be properly discussed here; but

there is no doubt that the alleged cœnenchymal gemmation—the special point brought forward by Waagen and Wentzel in favour of the alliance of these forms to Corals—certainly does not take place in *H. dendroidea*, and there is no satisfactory evidence that it occurs in the Indian species of the genus described by these authors. They further appeal to the figure given by Nicholson and Foord of *Fistulipora incrustans* (Ann. and Mag. Nat. Hist. ser. 5, vol. xvi. p. 501) as showing the same mode of increase by cœnenchymal gemmation; but it is evident that the figure referred to gives no indication of the development of the cells or autopores from the mesopores; it merely shows that the former have been sectioned obliquely. The real origin of the cells or autopores in this species is by growth from the basal lamina, precisely in the same manner as in *Hexagonella dendroidea* described above.

This species was originally placed by Mr. Hudleston in the genus *Exactinopora*, Meek and Worthen, but it has no close relationship to *E. radiata*, the type of this genus. It appears to me very doubtful whether the form named *H.* (*Exactinopora*) *crucialis*, Hudleston, is really distinct from *H. dendroidea*, as the difference consists merely in the mode of growth, a feature hardly of specific importance. *H. ramosa*, W. & W., though similar in mode of growth to *H. dendroidea*, has its cells only about half as large as in the latter species, and is consequently distinct.

Distribution.—Carboniferous, Gascoyne River.

Genus Rhombopora, Meek.

Rhombopora tenuis, Hinde sp.n. Pl. VIIIa. Figs. 4, 4*a*.

Imbedded in some pieces of rock from the Gascoyne River are several fragments of a small branching polyzoon, which in microscopic characters are similar to the genus *Rhombopora*. The specimens are cylindrical and branching, about 1·5 mm. in diameter; the cells spring from an imaginary central axis, and at first are nearly vertical or slightly oblique; they then curve somewhat abruptly and open approximately at right angles to the surface of the branch (Fig. 4*a*). In the axial portions the cells are subcircular in section, with thin walls; at the point where the outward curve commences, the walls are considerably thickened. The cell-apertures are oval, about ·2 mm. in width with definite fibrous margins; in the interspaces between them there are well-marked interstitial tubes and spines (Fig. 4). I have not recognized any tabulæ in the cells.

From a comparison with specimens and sections of *Rhombopora interporosa*, Phill. sp., kindly supplied me by my friend Mr. John Young, F.G.S., I find a very close resemblance in microscopic structure to the Australian species; at the same time there is also a certain resemblance to such forms as *Monticulipora ? tumida*, Phill. sp., and more particularly to a slender variety of this species from the Carboniferous strata of Northumberland, which has been named var. *miliaria* by Prof. Nicholson (Genus *Monticulipora*, p. 123, pl. iii. figs. 2, 2*c*).

Distribution.—Carboniferous, Gascoyne River. The specimens are associated in the same matrix with *Hexagonella dendroidea*.

EXPLANATION OF PLATES VIII. AND VIIIa.

PLATE VIII.

FIG. 1.—*Cyathophyllum virgatum*, sp.n.; 1*a*, a fragmentary specimen, natural size; 1*b*, transverse section enlarged two diameters.

,, 2.—*Cyathophyllum depressum*, sp.n.; 2*a*, the upper surface, showing the weathered summits of the corallites; 2*b*, a transverse section, enlarged.

,, 3.—*Pachypora tumida*, sp.n., natural size.

,, 4.—*Syringopora reticulata*, var. *patula*. Portion of a specimen, showing the corallites in section. Natural size.

,, 5.—*Aulopora repens*, Knorr and Walch.

,, 6.—*Hexagonella dendroidea*, Hudleston, sp. A section showing the thickness of the branch.

,, 7.—*Stromatoporella Fifeliensis*, Nicholson; 7*a*, 7*b*, specimens natural size; 7*c*, vertical section enlarged.

,, 8.—*Actinostroma clathratum*, Nicholson; 8*a*, vertical section natural size; 8*b*, portion of the same enlarged.

PLATE VIIIa.

FIGS. 1–1*f*.—*Plerophyllum australe*, Hinde.

,, 1*a*, 1*b*, 1*c*.—Three imperfect examples natural size; 1*b* shows the exterior surface in its natural condition; in 1*a* and 1*c* the surface has been weathered, and the median laminæ of the septa are exposed.

,, 1*d*.—A transverse section of the calice, with the small cardinal septum inclosed between two larger septa above. Enlarged 2½ diameters.

,, 1*e*.—A transverse section of another specimen, similarly enlarged, in which the smaller septa are proportionately more developed, and the small septum between the two larger is lateral in position.

,, 1*f*.—Another transverse section, similarly enlarged, in which one portion has been completely infilled by stereoplasm.

,, 2, 2*a*.—*Plerophyllum sulcatum*, Hinde.

,, 2.—An imperfect specimen, showing renewals of growth and the longitudinal rugæ of the surface.

,, 2*a*.—A transverse section of the same, enlarged 2½ diameters, showing complete solidification by stereoplasm.

,, 3, 3*a*.—*Polypora australis*, Hinde.

,, 3.—A fragmentary specimen showing the celluliferous surface, natural size.

,, 3*a*.—A portion of the same, enlarged 5 diameters, showing the form and disposition of the fenestrules and cell-apertures.

,, 4, 4*a*.—*Rhombopora tenuis*, Hinde.

,, 4.—A portion of the surface showing the cell-apertures and the interstitial tubes and spines. Enlarged 20 diameters.

,, 4*a*.—A portion of a longitudinal section, showing the disposition of the cells and the thickening of the walls near the surface.

,, 5–5*d*.—*Hexagonella dendroidea*, Hudleston, sp.

,, 5.—An imperfect stem or branch, showing the mode of growth, the linear ridges, the maculæ, and the cells of the exterior surface. Natural size.

,, 5*a*.—A portion of a transverse section of a branch, showing (in section) the median layer and the cells (=autopores) on it. Enlarged 20 diameters.

,, 5*b*.—A portion of a median longitudinal section of a branch, showing the recumbent position of the cells on the median layer in their first stage of growth, their subsequent vertical direction, the tabulæ traversing them at intervals, and the vesicular interstitial tissue of the central area. Enlarged 20 diameters.

,, 5*c*.—A portion of the surface of Fig. 5, enlarged 20 diameters, showing the oblique projection of the lips of the cells, the manner in which they are partially or entirely closed by calcareous lids, the tuberculate character of the interstitial areas, and the raised ridges.

,, 5*d*.—A portion of a tangential section, showing the cells with distinct walls, and the cloudy appearance of the solid interstitial substance of the outer zone of the branch. Enlarged 20 diameters.

II.—On some Epi-diorites of N.W. Ireland.[1]

By J. Shearson Hyland, Ph.D.

(Communicated by permission of the Director-General of the Geological Survey.)

In an Appendix to the Explanatory Memoir on Sheet 17 of the Map of the Geological Survey of Ireland (Dublin, 1889), I have furnished a description of the petrographical characters of the Epi-diorites of the district. Some of the facts elicited by the examination of the rocks are sufficiently interesting to deserve a wider circulation.

The rocks occur as sheets and dykes intrusive into the altered sediments (quartzites, mica-schists,[2] etc.), and at St. Johnstown and Raphoe they are seen to break through the stratified deposits transversely to the bedding.[3] In the field, a strong foliation is often to be recognized; but this structure is at times little developed and hardly perceptible. Still the absence of this macroscopic feature does not preclude the possibility of reconstruction having occurred; for it has been abundantly demonstrated that molecular re-arrangement can ensue without the development of such a structural modification.[4]

The specimens examined are greenish in hue and vary in grain from coarse to fine. The petrographical description is mainly based upon a collection made from the following localities:—

One mile N. of Raphoe; Half mile N. of Raphoe; Half mile N. of Convoy;	Co. Donegal.
Half mile S.E. of Drumahoe Bridge, and two miles S.E. of Derry; One mile and a half W. of St. Johnstown (Dooish Mountain); One mile and a half S.S.W. of New Buildings, and four miles S.S.W. of Derry;	Co. Londonderry.

The rocks described under the head "Epi-diorites" are plagioclase-pyroxene rocks which have undergone alteration under the influence of dynamic metamorphism. Most of them were originally dolerites (Ger. *Diabase*); but it is not improbable that the masses at one mile N. of Raphoe and half mile N. of Convoy represent altered gabbros.

As a result of the metamorphism, the pyroxene has been completely altered into a greenish monoclinic hornblende, which possesses the characters of "uralite." This mineral occurs in ragged patches, which in most cases still preserve the ophitic structure of the pyroxene which it has replaced. Where there has been movement coincident with or subsequently to this uralitization, the horn-

[1] Read before the Royal Geological Society of Ireland, 10th February, 1890.

[2] The dark bluish-grey mica-schist is seen under the microscope to consist of a plexus of light-green, uniaxial mica and minute grains of quartz. Calcite, hematite, tourmaline, and rutile are also present. Strain-slip cleavage is well developed. Iron-pyrites is to be observed macroscopically, also rutile according to Giesecke.

[3] Prof. Hull in Memoir to Sheet 17, p. 7.

[4] Teall, "The Metamorphosis of Dolerite into Hornblende-schist," Q.J.G.S. 1885, p. 139, and "The Metamorphosis of the Lizard Gabbros," Geol. Mag. Dec. III. Vol. I. p. 487.

blende becomes split up into innumerable fibres which partake in the general movement. A sort of lenticular structure is thus produced, the margins of the lenticles consisting of a felted hornblendic mass in a state of fine division. In the much altered varieties, the hornblende becomes decidedly actinolitic in character, forming long green or bluish-green prisms. As the actinolitic nature becomes the more evident the more decided the foliation, it is not surprising that planes of movement are coated with amianthus-like actinolite (one mile S.S.W. of New Buildings, Co. Derry). Liebe[1] has described the presence of primary hornblende in rocks of this type; but there is no evidence of an occurrence of this nature in those under examination. A colourless, tremolite-looking hornblende is sometimes apparent, but is not a constant accessory.[2]

Intergrown with and imbedded in the hornblende there are to be observed numerous patches and flakes of biotite. This mineral is singularly devoid of inclusions, and appears to stand in a genetical relation to the hornblende. The pleochroism is:—

α = pale straw colour.
β and γ = brownish-yellow to dark-brown.

Epidote and zoisite[3] are very common, whilst secondary quartz is not infrequent. There is also a little calcite present. The quantity of felspar varies more or less, but is always subordinate to that of the hornblende. It can eventually become very small, as the hornblende appears to displace the felspathic constituent. This almost entire disappearance of the felspar may account for the statement made over fifty years ago by G. Rose, that "uralite" was only to be found in those greenstones in which felspar was absent or little apparent.[4] Still, notwithstanding this opinion, put forth shortly after his discovery of the mineral, mention is especially made in his work on the Urals of the constant association of uralite and oligoclase.[5]

The metamorphism of the felspar leads to its "granulation," and the consequent formation of new products. This "granulation" is referred to a "crystallizing process going on under the influence and

[1] Uebersicht ueber den Schichtenaufbau Ostthüringens, Abhandl. zur geol. Spezialkarte von Preussen u. d. Thüring. Staaten, Band V. Heft 4, p. 83.

[2] Tremolite occurs in the district comprised in Sheet 17, viz. near Curley Hill, Co. Tyrone, but in limestone. (C. L. Giesecke, Minerals of the Royal Dublin Society, to which is added an Irish Mineralogy, Dublin, 1832, p. 227.)

[3] For crystallographic details, see Memoir, Sh. 17, pp. 35 and 36. The occurrence of zoisite in this district, at Holly Hill, near Strabane, Co. Tyrone, was known to Portlock (Report of the Geology of the Co. Londonderry, etc., Dublin, 1843, p. 209); also to Giesecke (*loc. cit.* p. 208).

[4] Pogg. Ann. d. Ph. 1833, 1 St. p. 103. "Immer aber haben sie (Uralite) sich nach den gemachten Erfahrungen nur in den Grünsteinen gefunden in welchen Albit oder Feldspath nicht vorkommen oder wenigstens nicht deutlich ausgeschieden vorkommen; mit der Bildung dieser Mineralien scheint die Bildung des Uralits aufzuhören und statt dessen *Hornblende* an seine Stelle zu treten." The term "uralite" is used in a strict sense as applying to a mineral possessing the outer form of augite and the cleavage planes of hornblende (V. Pogg. Ann. 1831, xxii. p. 321; and Jahrb. f. Min. 1832, p. 237).

[5] "Reise nach d. Ural," Band II. 575.

control of powerful mechanical stresses."[1] The original felspathic constituent was a labradorite. Some few well-developed lath-shaped sections, parallel to the M-face, give an extinction of $-30°$; this denotes the presence of a felspar allied to $Ab_1\ An_3$. Such sections show the albitic lamellation. The mass of the felspar is, however, particularly striking owing to the want of this striation, to its granular condition, and to its occurrence in conjunction with quartz and epidote. This combination of minerals forms under crossed Nicols the so-called "quartz-felspar-(epidote)-mosaic": it bears every aspect of being secondary, and recalls the metamorphism of labradorite ($Ab_1\ An_2$ according to Schilling[2]) into albite with bye-products, as has been described by Lossen in the case of the Hartz diabases.[3] The similarity being so strong, we may therefore assume that a like alteration has been effected in the felspar of our Irish Epi-diorites.

The albitic character of the secondary felspar has been inferred from the analyses of the vein-felspars so frequently observed in rocks of this class. Gümbel[4] supplies, for instance, an analysis of a vein-"albite" from the Fichtelgebirge, whilst Teall[5] gives the composition of the vein-felspar in the Scourie Dyke in Sutherlandshire as that of andesine. From his analysis I have calculated the admixture of orthoclase, albite, and anorthite to be as follows:—

			Orthoclase. 10·40%		Albite. 59·06%		Anorthite. 28·78%
SiO_2	58·16	=	6·72	+	40·54	+	12·42
Al_2O_3	26·66		1·92		11·53		10·57
CaO	5·79		—		—		5·79
MgO	·65		—		—		—
Na_2O	6·99		—		6·99		—
K_2O	1·76		1·76		—		—
	100·01		10·40		59·06		28·78
				2·4			1

This would represent a felspar of the constitution An_1, $Ab_{2\cdot4}$, *i.e.* a felspar intermediate between andesine and oligoclase.

It would manifestly be more accurate to analyse the felspar which occurs in the ground-mass of the rock itself; but no attempt has apparently been made in this direction owing to the difficulties the isolation presents. In order to do this, the rock from Convoy was taken, and, after being powdered, treated with weak acid in order to remove the small quantity of calcite present. The secondary felspar was then separated by means of the Sonstadt-solution: its specific gravity was found to be 2·645. The analysis gave the following result:

[1] Judd, "On the Processes by which a Plagioclase Felspar is converted into a Scapolite," Min. Mag. viii. No. 39, p. 186 (13).

[2] "Grünsteine des Harzes," Göttingen, 1869.

[3] "Studien an metamorphischen Eruptiv- und Sedimentgest," Jahrbuch d. k. preuss. geol. Landesanstalt für 1883, Berlin, pp. 619–640. Also, Erläuterungen zur geol. Specialkarte von Preussen, Blatt Wippra, 1883, pp. 50 and 83.

[4] "Die palaolithischen Eruptivgesteine des Fichtelgebirges," München, 1874, p. 14.

[5] British Petrography, p. 155.

			Orthoclase. 2·11%	Albite. 71·49%	Anorthite. 22·31%
SiO_2	62·86	= 62·74 =	1·36 +	49·07 +	9·63
Al_2O_3	20·1	20·06 }	0·39	13·96	8·19
*Fe_2O_3	2·6	2·59 }			
CaO	4·5	4·49	—	—	4·49
K_2O	0·36	0·36	0·36	—	—
Na_2O	8·48	8·46	—	8·46	—
H_2O	1·3	1·3	—	—	—
	100·20	100·00	2·11	71·49	22·31
				3·3	1

The constitution of the secondary felspar may be considered as $An_1\ Ab_{3\cdot3}$. The molecular rearrangement of the original labradorite ($Ab_1\ An_3$) has resulted in the formation of a felspar allied to oligoclase. We have accordingly the association of uralite and oligoclase in the rocks, and it is hence interesting to recall G. Rose's observations upon the subject. (*Vide supra.*)

Owing to this alteration of the felspar, a large amount of lime was set free, which induced the formation of epidote and zoisite. The aggregates of these two minerals are sometimes found piercing the bi-silicate in continuous lines, and thus preserve the ophitic structure so characteristic of dolerites.

Iron-pyrites and ilmenite are present: the latter is mostly altered into granular aggregates of sphene. The amount of chlorite and quartz is naturally in direct proportion to the degree of alteration the rock has undergone. Apatite is rare.

There is no evidence of the presence of either scapolite or sahlite in the specimens examined. It is, however, highly probable that both these minerals are to be met with in the greenstones of this district, as Sir Charles Giesecke records their occurrence at the old lead-mine in the neighbourhood of Strabane, Co. Tyrone.[1] The scapolite shows a "four-sided prism"; whilst the sahlite is described under the old name "baikalite." The same mineralogist calls attention to the presence of "silver-white, pearly mica, resembling lepidolite," at Holyhill, Co. Tyrone, where he also observed lievrite.

14, *Hume Street, Dublin.*

III.—The High Continental Elevation preceding the Pleistocene Period (in America).

By Prof. J. W. Spencer, A.M., Ph.D., F.G.S.,
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(Read before the Geol. Soc. Am., August, 1889.)

IF, in the growth of the American continent, the moulding of the land features had not largely depended upon its projection above the sea, favouring or retarding the action of rains and rivers,

* The Fe_2O_3 was estimated by titration: the amount is certainly high; but the sp.g. of the powder (2·645) shows that it cannot be ascribed to the presence of epidote. 2·59% of Fe_2O_3 would be equivalent to an admixture of about 5·8% of epidote, which would demand a sp.g. of about 2·9 (*cf.* Cathrein, "Ueber Saussurit," Zeits. f. Kryst. vii. 241-242).

[1] *loc. cit.* pp. 208 and 219.

in sculpturing its surface, there would be little interest as to what was its relative height, before the commencement of the Pleistocene period. But we find valleys vastly greater than meteoric agents could have produced under existing circumstances. Thus, there are not only deep *cañons*, but also vast depressions, descending to levels far below the sea, which are now filled with the earlier drift accumulations, or form channels submerged beneath ocean waves, or constitute basins occupied by lakes. Hence, in the study of the drift itself, in the investigation of the lake history, or in the research upon the growth of modern rivers, we necessarily inquire what was the altitude of the continent that would permit of the mouldings and channellings of the original rock surfaces.

Following the period of high continental elevation, the geologist sees in the valleys and old channels, still below the level of the sea, and in the high level beaches, an extensive submergence, succeeded by a re-elevation, but not to the original height, when the continent was being chiselled out by the ancient rivers. That this re-elevation is still going on is shown by the northward tilting of the comparatively recent marine accumulations, along the St. Lawrence valley and gulf coast, and the raised beaches in the Lake region, as well as by the shoaling of the waters of Hudson Bay during the present period of observation.

As general statements do not satisfy investigation, it becomes necessary to search for definite measurements of the former height of the continent among the archives of the geological past. Let us first seek for the testimony recorded by the Mississippi River.

For the distance of eleven hundred miles, measured in a direct line, above the mouth of the "Father of Waters," the modern valley is merely maintaining its own size, or more generally is being slowly filled by the deposition of river alluvium upon its floor. There are only two exceptions, of a few miles each, where the river is scouring out the rocky floor, and these are over barriers recently exposed, during changes of the Pleistocene period. To such an extent has the ancient valley or *cañon* been filled, first with drift, and this covered with river alluvium, that its original rocky floor is now buried to a depth of 170 feet,[1] even at La Crosse, a thousand miles from the Gulf of Mexico. Farther south, the depth of these loose deposits increases, until at New Orleans a boring of 630 feet[2] below sea-level does not penetrate the southern drift, nor even reach to its lowest members. The lower 500 miles of the ancient Mississippi were excavated out of Eocene or Cretaceous deposits, whilst the valley above the mouth of the Ohio has the form of a *cañon* excavated out of Palæozoic rocks, varying in width from two or three to ten miles, and having a depth (exclusive of the nowfilled portion) of from 150 to 550 feet.[3]

From this inspection of the river, it is easily seen that no natural

[1] Geol. Wis. vol. i. p. 253.
[2] Prof. E. W. Hilgard, Am. Journ. Sc., Nov. 1869, p. 333.
[3] Val. Min. and Miss. to Junct. of Ohio; Gen. G. K. Warren, Rept. Eng., U.S.A., 1878.

rainfall could so increase the volume of the discharge as to remove all the deposits which now fill the old valley, much less excavate the original and immense *cañon*. A vastly greater elevation of the continent would be necessary. Even were the whole continent uniformly elevated 630 feet together with the remainder of the unknown depth of the ancient Mississippi River at New Orleans, the *cañon* of the upper part of the river would require a still greater relative elevation of the northern country, in order to give sufficient channelling power to the flowing waters. But the slope of the floor of the buried valley is much less than that of the modern one, as was formerly shown by the author.[1] Here, again, is the proof that the country drained by the upper waters of the Mississippi once stood much higher than at present, relatively, to that of the region nearer its mouth. Of the amount, which was at least many hundreds of feet, we have no absolute measurement. Nor can we ascertain it by calculation, for there is no registry of the excess of the amount of rainfall, during the epoch of the greatest sculpturing, over that of the present day.

Whilst these records of the Mississippi, which have been only partially deciphered, do not furnish all the desired information, yet, as far as they go, they are invaluable.

Passing from the buried channel of the Mississippi to its continuation, now submerged beneath the waves of the Gulf of Mexico, we find evidence indicating such a stupendous continental elevation as to be almost incredible were it not supported by collateral evidence, upon both the Pacific and Atlantic coasts. The soundings off the coast of the delta of the Mississippi indicate the outer margin of the continental plateau as submerged to a depth of 3600 feet,[2] indented by an embayment of another hundred fathoms in depth, at the head of which there is a valley, a few miles wide, bounded by a plateau from 900 to 1200 feet above its floor. This valley is now submerged to a depth of over 3000 feet, and is the representative of the channel of the ancient Mississippi River, towards which it leads.

On the Pacific coast, in the region of Cape Mendocino, Prof. George Davidson has identified three valleys now submerged to from 2400 to 3120 feet, and several of inferior depth. These measurements are those of the valleys where they break through the marginal plateaux of the continent, at about six miles from the present shore, where it is submerged to the depth of a hundred fathoms.[3]

The soundings along the Atlantic coast reveal similar deep fjords. The extension of the Hudson River beneath the Atlantic waters, known long since, is traceable to the margin of the continental plateau, show a bar, covered with mud, which, however, is now submerged to the depth of only 1230 feet.[4] acquiring a depth of 2844 feet, in front of which the soundings

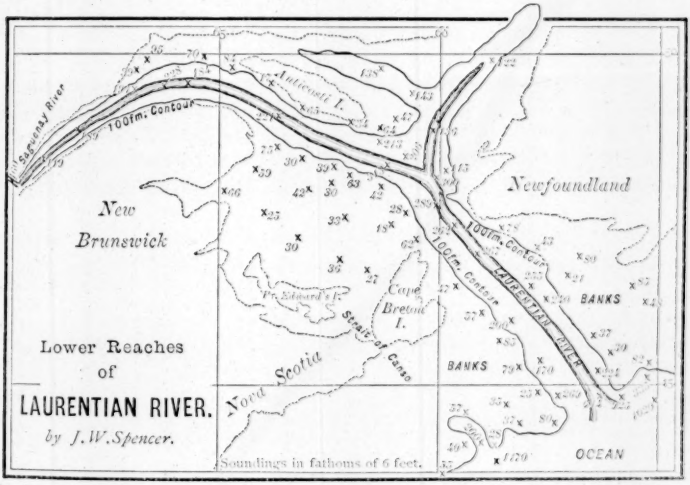
The as yet unpublished soundings off the mouth of the Delaware

[1] J. W. Spencer, "Warping of the Earth's Crust," etc., Am Nat., Feb. 1887.
[2] J. W. Spencer, "The Miss. River, etc." 1884. See also Coast Survey Charts.
[3] Prof. George Davidson, Bull. Cal. Acad. Sc., ii. 6, 1887, p. 265.
[4] A. Lindenkohl, Appendix, No. 13, Rept. U.S. Coast Survey, 1884, pp. 270-273.

River bring to light another valley, the floor of which is now covered by ocean waves to nearly 1200 feet—its continuation seaward not having been ascertained.

Were the continent elevated only 600 feet, the Gulf of Maine would be replaced by a terrestrial plain, in some places 200 miles wide, but traversed by rivers, one of which towards its mouth would be 2064 feet deep, that is to say, the bottom of the fjord is now submerged 2664 feet. Even this great depth may not be its maximum, for along the line between the opposite banks, at the mouth, now beneath a hundred fathoms of water, we find that the sea is nearly 5000 feet deep. Whether this represents an embayment of the ocean, setting towards the valley, or a continuation of the fjord, is not determined.[1]

The St. Lawrence River and Gulf bear the same testimony to the existence of deep fjords extending from the rivers through the now submerged plateau forming the margin of the continent. The lower part of the Saguenay River flows between stupendous walls, and constitutes a fjord whose waters reach a depth of 840 feet. In the



St. Lawrence River, a little below the mouth of the Saguenay, there is a channel 1134 feet below the surface. This increases in depth in passing seaward. In the region of the centre of the modern gulf the floor of the old channel is now submerged 1878 feet, and the adjacent valley 1230 feet, thus showing the *cañon* as being over 600 feet deep. As at the mouth of the channel through the Gulf of Maine, so at the mouth of that of the St. Lawrence, there is a deep chasm, for enclosed between the banks, a hundred fathoms below the surface, there is now the depth of 3666 feet, with water 2000 feet deeper just seaward of it. Although this ancient valley is over sixty miles wide at its mouth, with a narrower channel, yet it is not as broad as some portions of the modern so-called river. The

[1] U.S. Coast Survey Charts.

breadth of the submerged valley throughout its windings for a length of 800 miles or more, is remarkably regular, only gradually increasing its magnitude in passing seaward. Other lesser channels are visible in the soundings; thus south of the Straits of Canso, between Nova Scotia and Cape Breton Island, there is one 1200 feet deep, where adjacent soundings show less than 600 feet of water.

Hudson Bay rarely exceeds a depth of 600 feet, yet at the outlet, the channel is 1200 feet deep. This depth increases in passing down the Straits, where the scanty soundings show 2040 feet, before reaching the mouth. Here, in Hudson Straits, the old valley is a chasm across a mountain system, whose peaks, upon the southern side, rise to 6000 feet above tide. The *cañon* of the St. Lawrence also crosses the trend of two mountain systems, but these are of no great height. The same is not true for any of the other submarine valleys described.

The record of a former high continental elevation is again inscribed in the depths of the Great Lakes—Ontario reaching to 491 feet below ocean-level; Superior to nearly as much; Michigan to 300; and Huron to 150 feet. The lake basins are merely closed-up portions of the ancient St. Lawrence valley and its tributaries. Their distance from the sea would necessitate not merely a general elevation of the continent, but also a greater amount of elevation towards the head-waters of the system, as has been shown with regard to the excavation of the upper portion of the ancient Mississippi *cañon*. The lake-basins are all excavated out of Palæozoic rocks, except a part of that of Lake Superior.

The soundings do not afford all the information that we desire, yet they demonstrate the presence of submarine valleys reaching upon all our coasts to depths of more than 3000 feet. Again, the soundings show that to within comparatively short distances from their mouths, the depths of the valleys below the surface of the seas sometimes did not exceed from 1200 to 1800 feet, but that beyond there was a great increase in depth within the last few leagues.

Whilst depressions in the earth's surface are made and modified by terrestrial crust movements, yet the leaving open of great yawning chasms is not of sufficiently well-known occurrence to attribute all the submerged valleys upon the American coasts to such an origin, especially when we consider the great length of the submerged channel of the St. Lawrence River (800 miles), its various windings, and its uniformly increasing size, until it passes into the great chasm, just before it reaches the margin of the continent.

The idea of the excavation of these submerged valleys by glaciers, some of which are outside of glacial regions even of the past, is too untenable for a moment of serious consideration. Irrespective of the causes which have determined the location of the channels here described, it appears that they have been made one and all by the excavating power of rivers and lateral streams pouring down the hill-sides. These, together with other meteoric agents, have also to a greater or less extent removed the Palæozoic and the Triassic

rocks, from the depressions now occupied by the Gulfs of St. Lawrence and Maine, which have, however, been more or less affected by terrestrial movements.

The length of time required to excavate the channels of these great rivers commenced as far back as the Palæozoic days. However, the culmination of that of the Mississippi was not until in the later Tertiary, before the Pleistocene period. As the St. Lawrence, now submerged to a depth of over 1200 feet for a distance of 800 miles, is mostly cut out of rocks of the Palæozoic group, except a belt of the Triassic (across the lower portion, more or less involved in mountain uplifts), its antiquity must be very great. The culmination was also probably in the later Tertiary era, like that of the Mississippi, and the channels on the California coast, for there are submerged Tertiary rocks off the coast of Massachusetts and Newfoundland, at elevations much higher than the beds of the old channels.

Although the excavating forces took so many periods to form the valleys, and required a high continental elevation, yet the extreme altitude of over 1800 feet appears to have been of comparatively short duration, for otherwise the deep chasms in which the submerged channels terminate would have extended farther inland than we find them, and would have been headed by more gentle slopes, in place of precipitous cliffs, over which the waters of the former rivers were precipitated in great cascades. In the fjords of Norway, merging into rapidly contracting valleys, or headed by great vertical walls, hundreds of feet in height, having the structure named *cirques*, may be seen to-day the counterpart of the coast of the American continent, when its marginal plateaux stood over 3000 feet higher than at present; yet Norway stood once much higher than now, but was afterwards submerged, from which depression it has only recently been re-elevated so that its plateaux, close upon the sea, rise to three or four thousand feet, and its mountains still higher.

The old hydrography is more or less disturbed by warpings of the earth's crust, which, however, do not obscure the valleys, although rendering the features somewhat more complex. The amount of distortion has yet to be determined.

IV.—Woodwardian Laboratory Notes.

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1.—Specific Variation in *Sigillariæ*.

NO better example could perhaps be quoted of fossil plants which have given rise to a number of species and even genera founded on imperfect and fragmentary specimens than the *Sigillariæ* and *Lepidodendra*.

Our knowledge of the internal structure of these plants has so far increased in recent years that we are now able to appreciate the differences between stems or branches of plants which have been

preserved with their cortical tissues entire, and those which have been to a greater or less extent decorticated.

Genera like *Knorria*, *Aspidiaria*, *Bergeria*, and others are now generally recognized as imperfectly preserved Lepidodendoid stems.

We propose to confine ourselves in the present instance to the *Sigillariæ*. As a general rule, for purposes of classification and specific determination, we have to rely on certain external characters of the stems or branches. Seeing how the surface of a partially decorticated stem differs in appearance from that of a stem with its outermost cortical tissues preserved, one cannot be too careful in selecting well-preserved specimens before venturing to make any definite statements as to specific character. Mr. Kidston[1] lays special stress on this point. He remarks: "When determining the various species of the genera *Lepidodendron* and *Sigillaria*, unless the outer surface of the bark is well preserved and exhibits the form and arrangement of the leaf-scars, it is admitted that the plants do not show the characters by which a specific, or even in some cases a generic determination can be made."

The *Sigillariæ* may be divided into four sections or groups, *Rhytidolepis* (Sternberg), *Favularia* (Sternberg), *Clathraria* (Brongniart), and *Leiodermaria* (Goldenberg); or a more convenient classification is that adopted by M. Zeiller,[2] and others, where we have only three sections, *Rhytidolepis*, *Clathraria*, and *Leiodermaria*.

Such a classification as this, although convenient, is necessarily unsatisfactory, and one must expect from time to time evidence to be forthcoming which tends to break down the artificial barriers or fill up supposed gaps between the representatives of the several sections.

Some striking examples have recently been brought forward by Herr Weiss, of Berlin, and M. Zeiller, of Paris, of connecting links between two of these sections.

It may not be without interest to give a short resumé of the three papers in which proofs are given of the gradual passage from a type figured by Solms-Laubach[3] as representative of one section, *Leiodermaria*, to one quoted by him as an example of another section, *Clathraria*.

In the "Zeitschrift der Deutschen Geologischen Gesellschaft," for 1888, p. 565, there appeared a short notice by Weiss, "Ueber neue Funde von Sigillarien in der Wettiner Steinhohlengrube." In this paper he deals especially with specimens of *Sigillaria* recently found in the Coal-measures of the Wettin district, *Sigillaria spinulosa* (Germar), belonging to section *Leiodermaria*, and *S. Brardi* (Brongniart), one of the *Clathrariæ* (*Cancellatæ*, Weiss). To quote Weiss's words—"Of exceptional interest is a large series of specimens which, beginning with *S. spinulosa*, gradually passes, almost without a break, into *S. Brardi*. In this case there is no recognizable division between *Leiodermariæ* and *Cancellatæ*, indeed it is

[1] Ann. and Mag. Nat. Hist. vol. xvi 5th series, p. 123.
[2] Flore fossile du bassin houiller de Valenciennes, p. 512.
[3] Einleitung in die Palaophytologie, p. 249.

difficult to separate the species of this series from one another." He goes on to describe Germar's[1] *S. spinulosa*, characterized by an even surface and peculiar small scars occurring below the leaf-scars, probably representing points of attachment of roots; these scars, which gave rise to the term *spinulosa*, are found to be by no means constant in their occurrence. Some specimens are mentioned by Weiss, from the Halle Collection, which agree in all points with *S. spinulosa*, except that the root (?) scars are absent; the surfaces of these specimens are marked with longitudinal and transverse wrinklings. Immediately below the leaf-scars the transverse wrinklings appear more prominent than the longitudinal, and this region becomes to some extent emphasized or distinct. In all the specimens these transverse and longitudinal wrinklings occur more or less pronounced; the subquadrate form of the leaf-scar is another fairly constant character. On examining the series of specimens Weiss noticed that the leaf-scars were farther apart in the forms with an even stem surface, and that the distances between them diminished as the leaf-cushions became more and more developed, or, in other words, as the *Clathraria* character became more marked. Four figures are given, showing a passage from a *Leiodermarian* form in which the wrinklings on the surface of the stem are very conspicuous, and in which there is an indication of undulating lines between the leaf-scars, through an intermediate form, called by Weiss *S. Wettensis*, to the typical *S. Brardi*. As the leaf-cushions become more and more completely formed, the surface wrinklings become less and less conspicuous. Clear evidence is given of an intimate connexion between the two sections *Leiodermaria* and *Clathraria*.

In the Neues Jahrbuch für Mineralogie, etc. (Jahrgang 1889, p. 376), Weiss brings forward further evidence of the absence of any definite line of demarcation between *Leiodermarian* and *Clathrarian* types. A piece of thick, somewhat flattened stem, is described from the collection in the Halle Museum, showing on one side the *Clathrarian* type *S. Brardi*, and on the other side the *Leiodermarian* type *S. spinulosa*. A second specimen is referred to from Halle which shows a passage from a form resembling *S. Defrancei* (Brongniart), one of the *Clathrariæ*, to a *Leiodermarian* form. The facts adduced by Weiss are considered by him to show that in certain cases the *Leiodermaria* form of surface represents a later, the *Clathraria* form an earlier state of the plant's growth. This does not, says Weiss, hold good probably in all cases; possibly many *Sigillariæ* have *Leiodermarian* characters during the whole of their life, and others retain *Clathrarian* characters. Some cases, however, occur where the two types are simply expressions of differences in age or development.

Weiss divides the *Sigillariæ* into two main groups:—

A. *Subsigillariæ.*		B. *Eusigillariæ.*	
1. *Leiodermariæ.*	2. *Cancellatæ.*	3. *Favulariæ.*	4. *Rhytidolepis.*

[1] Die Versteinerungen des Steinkohlengebirges von Wettin und Löbejün. taf. xxv.

It is known that *Favulariæ* and *Rhytidolepis* pass into *Cancellatæ* and *Favulariæ*; that *Leiodermariæ* pass into *Clathrariæ* has already been shown. One may quote here, as bearing on the remarks of Weiss, a sentence from Solms-Laubach,[1] "Whilst *Rhytidolepis*, *Clathraria*, and *Favularia* are connected with one another by intermediate forms, the same cannot be said of the *Leiodermariæ*, in which the leaf-cushions, as such, are entirely wanting, and on whose perfectly smooth cortical surface the leaf-scars are situated at a considerable distance from one another." In the "Bulletin de la Société géologique de France,"[2] M. Zeiller publishes some interesting notes, "Sur les Variations de formes du *Sigillaria Brardi*, Brongniart," in which he begins by referring to the attempt made by Boulay[3] to reduce the unnecessarily large number of species of *Sigillaria*. Zeiller[4] himself has pointed out certain differences which should be referred to differences in growth, and are not such as to justify the separation of distinct species.

A photograph is given by Zeiller of a specimen of *Sigillaria* showing perfectly clearly that *Leiodermarian* and *Clathrarian* types pass into one another. In the upper part of this specimen the leaf-scars are very prominent, broader than high, and separated by well-marked grooves, in fact we have here the characters of *S. Brardi*. Towards the lower end of the specimen the grooves gradually disappear and the leaf-scars get farther apart, the cushions become less and less distinct and the surface becomes even, having the characteristic wrinkling ornamentation. Still further towards the lower end the leaf-scars tend to come together again. The middle part of the specimen corresponds very closely, except in having no root (?) scars, with *S. spinulosa*. "*S. spinulosa* is then only a condition of *S. Brardi*, corresponding to a more rapid elongation of the stem or branches." By examining very carefully the *S. spinulosa* part of the specimen, a slight indication can be detected of the leaf-cushions, which become gradually more pronounced, until we have finally *S. Brardi*. In other parts the surface of the stem is perfectly even, and no traces of leaf-cushions can be seen. M. Zeiller points out that, in spite of these variations, there are certain features which remain constant; the form of the leaf-scars, the relative position of the cicatriculæ on the leaf-scars, and the mode of ornamentation of the bark. M. Zeiller[5] has previously given what he considers the most constant characters on which to rely in the determination of species. In the present paper reference is made by Zeiller to a specimen of *S. spinulosa* described by Renault showing leaf-scars on the fruit-bearing branches corresponding in shape and position to those of *S. Brardi*.

Attention is called to the fact that although such apparently different types as *S. spinulosa* and *S. Brardi* have been shown to be

[1] *loc. cit.* p. 251.
[2] 3e sér. t. 17 (1889), p. 603.
[3] Le terrain houiller du Nord de la France, p. 47.
[4] Flore foss. du bassin houiller de Valenciennes, p. 513.
[5] *Ibid.* p. 513.

simply different conditions of one and the same plant, yet there are certain distinctions and constant characters which must keep us on our guard against uniting as one species what are really distinct forms. One of the examples cited in illustration of this is *S. Moureti*, which suggests a very close relationship with *S. Brardi*; it is distinguished, however, from *S. Brardi* by the complete absence of an indentation on the upper edge of the leaf-scars, by the higher position which the cicatriculæ occupy on the leaf-scars, and by the round form of the lateral cicatriculæ placed somewhat above the central or vascular bundle cicatricula.

As further illustrating the variations in size of the leaf-cushions and leaf-scars on one and the same specimen I may add a few notes on three specimens which I had the opportunity of examining last year in the museums of Berlin and Breslau.

1. *Sigillaria* of *Rhytidolepis* type from the Coal-measures of Altenessen; in the Bergakademie Museum, Berlin. This specimen serves to show the differences in the size of the leaf-scars, the variation in breadth of the furrows and in the distances between the scars. Four ribs shown, three rows of leaf-scars. Breadth between ribs 1 & 2 = 3cm.; between ribs 2 & 3 = 2·3cm. Length of leaf-scar between ribs 1 & 2 = 9 mm.; breadth of ditto = 1·2 mm. The distance between the leaf-scars in the first furrow, *i.e.* between ribs 1 & 2, varies from 1·1 cm. to 1·3 cm. Length of leaf-scar between ribs 2 & 3 = 1 cm.; breadth of ditto = 8 mm. The leaf-scars in the third furrow, *i.e.* between ribs 3 & 4, correspond closely with those in the second furrow. The specimen agrees closely with *S. principis* (Weiss) and *S. lævigata* (Brongniart).

2. *Sigillaria* from Coal-measures of Bochum; in the "Goeppert Collection," Breslau University Museum. Length of stem, 28 cm.: average breadth = 6 cm. Details not very clear. At the upper end the leaf-scars and cushions are of the *Rhytidolepis* type: the distance between these leaf-scars = 3 to 4 mm. Breadth of leaf-scar = 3·5 mm.; length = 3·5 mm.

Passing down the stem the leaf-scars rapidly get closer together, until they are almost contiguous, showing a passage from a *Rhytidolepis* to a *Favularia* type. Towards the lower end of the specimen are indications of vertical fruit-bearing scars, below this the leaf-scars become farther apart again. Zeiller[1] figures a specimen showing a somewhat similar case of variation in the distances between the leaf-scars (*S. Sauveuri*, Zeiller).

3. *Sigillaria*. Specimen in the "Goeppert Collection."

The leaf-scars of the upper part have a breadth of 4·5 mm., and a length of 2 mm.; on the lower part the leaf-scars have a breadth of 2·5 mm., and a length of 2 mm. The former agree closely with *S. microrhombea* (Weiss),[2] var. *nana*, the latter with *S. cancriformis* (Weiss), vars. *Paulina* and *S. acarifera*.

[1] *loc. cit.* pl. lxxxiv. fig. 1.

[2] For figures of Weiss's species, v. "Die Sigillarien der Preussischen Steinkohlengebiete," Abhand. zur Geolog. Special-Karte von Preussen und den Thüringischen Staaten, Band VII. Heft. 3, Taf. vii. and xiv.

2.—*Tylodendron*, Weiss, and *Voltzia heterophylla*, Brongn.

In 1869 Prof. Weiss instituted a new genus *Tylodendron*, which he defined as follows:[1]—"Plantae arboreae, amplis intervallis ramosae. Rami teretes, longi crassique, obtuse terminati, pulvinis rhombeis plus minusve elongatis et acuminatis spiraliter dispositis aequalibus vel repetito-abbreviatis tecti. Pulvinorum pars superior sulco acuto ab altissima pulvini parte oriente in crura bina parallela contigua longissima divisa. Corpus ligneus vasa porosa poris 1-, 2-, 3-seriatis confertis et radios medullares notatos exhibens; annuli lignosi inconspicui."

The general characteristics of the genus are considered to be those of a Conifer;[2] the only point in which a difference exists being the presence of a slit in each of the elongated areolæ: this slit Weiss regards as an indication of the former existence of a resin-canal, like those which occur in the leaves and stems of our recent Conifers. It is suggested as possible[3] that the present surface of the fossil, which is covered with rhombic areolæ, may represent the internal cast of a stem.

Dr. Potonié, of Berlin, contributed a paper to the "Jahrbuch der Königl. preuss. Geologischen Landesanstalt for 1887, p. 311,[4] in which he gave the results of a detailed examination of several specimens and sections of *Tylodendron*; he arrived at the conclusion that *Tylodendron* is not the wood, but the pith of a Conifer, probably that of an *Araucaria*. *Artisia* is referred to as a similar case of a pith-cast, whose true nature was first brought to light by an examination of sections showing internal structure. Pith-casts of *Stigmaria* occur which bear a close resemblance to *Tylodendron*. Potonié cites figures given by Williamson[5] as instances of such casts: fig. 65 of Williamson's monograph shows, for example, not only similar rhombic areolæ, but also the slits extending along half the length of each areola as *Tylodendron*. Weiss has figured his specimens of *Tylodendron* in an inverted position, he regarded the pointed end of the specimen in Tab. xix. and xx. as representing the tapering off of the stem towards the upper end: as a matter of fact, according to Dr. Potonié, the slit extends from the *lower* end of each rhombic areola, and marks the position of the foliar bundles, as that in *Stigmaria* shows the position of the rootlet bundles.

Dr. Potonié has examined a large number of recent coniferous stems, and finds that a cast of the medullary cavity of *Araucaria brasiliana* closely resembles small specimens of *Tylodendron*.[6] I

[1] "Fossilen Flora der jüngsten Steinkohlenformation und des Rothliegenden im Saar-Rhein-gebiete," p. 182.

[2] Parkinson figures a fragment of what appears to be *Tylodendron*; no locality is mentioned, see "Organic Remains of a Former World," vol. i. pl. iii. fig. 4.

[3] Fossilen Flora der jüngsten Steinkohlen, etc., p. 183.

[4] "Ueber die fossile Planzen-Gattung *Tylodendron*." Three plates accompany this paper, illustrating the external appearance and microscopic structure of *Tylodendron*.

[5] "A Monograph on the Morphology and Histology of Stigmaria Ficoides. (Palæontographical Society, 1887), pl. xiii. figs. 64 and 65.

[6] Potonié, *loc. cit.* Taf. xiii. a.

have had an opportunity of seeing the original specimens on which Weiss founded his genus, and also the casts taken by Potonié of medullary cavities of recent Conifers. I was at once struck with the practical identity of the two sets of specimens, and felt convinced of the correctness of Potonié's conclusions.

In looking through the collection of fossil plants in the Strassburg Geological Museum, I found a specimen of *Voltzia heterophylla* which seemed to me a most interesting example of a case, in which what looks like a cast of an entire stem covered with elongated leaf-bases, should in reality be considered as simply a cast of the medullary cavity.

The elongated areolæ, I consider, correspond to those of *Tylodendron*, and represent casts of the inner ends of the primary medullary rays. All that remains of the wood and cortical tissues is a small amount of carbonaceous matter on either side of the central cast. In this specimen of *Voltzia* the areolæ are more elongated than in *Tylodendron*; but in both cases we have the slit extending upwards from the lower end of the areolæ representing the position of the foliar bundles. The *Voltzia* cast shows no periodic swellings as in *Tylodendron*, nor any alteration in the length of the areolæ such as occurs in the neighbourhood of the swollen portions of the latter genus. Similar swellings and accompanying variations in the length of the areolæ occur in casts of medullary cavities of recent *Araucariæ* at points where verticils of branches are given off. The specimen referred to closely resembles those figured by Schimper[1] from the same locality—Soulx-les-Bains. The axis, which consists of an iron-stained core, projects above the surface of the rock; the elongated lozenge-shaped areas are not sufficiently well preserved in all parts to be accurately measured; but in Fig. 1, I have attempted to represent a few of them as correctly as possible. On each side of the iron-stained axis are traces of carbonaceous matter; some also occurs here and there on the axis itself. In the Palæontographica for 1886[2] Dr. Blanckenhorn figures and describes some fragments of what he considers *Voltzia heterophylla*: these figures agree closely with the specimen here described. Blanckenhorn's specimens are described by him as branches from which the leaves have fallen, their surfaces being covered with long leaf-cushions separated from one another by furrows: each cushion has a groove extending from the lower end to the middle. The close resemblance of these

FIG. 1. — Length of areola 1 = 8 mm. 2 = 9 mm. 3 = 1 cm.

[1] Schimper et Mougeot, Plantes Fossiles du grès bigarré, pt. 1, tab. xiv. etc.

[2] "Die Fossile Flora des Buntsandsteins und des Muschelkalks der Umgegend von Commern" (Palæontographica, Band xxxii.), p. 135, tat. xxii. 18–20.

branches to *Tylodendron* is pointed out by Blanckenhorn, who agrees with Weiss that the slits in the so-called leaf-cushions represent resin canals.

That these specimens described by Blanckenhorn are really casts of medullary cavities of *Voltzia heterophylla* I have no doubt; what he took for leaf-cushions, and what Weiss regarded as such in the case of *Tylodendron*, are the casts of the internal ends of the medullary rays, and represent radial prolongations of the medullary tissue.

V.—The Physiography of the Lower Trias.

By A. J. Jukes-Browne, B.A., F.G.S.

THE question of the physical conditions under which the Lower Triassic sandstones and pebble-beds were formed is certainly one which should interest all readers of the Geological Magazine, if only that it is strange that it should still be an open question whether so important a formation is of marine or fluviatile origin.

Perhaps a few words from one who takes a keen general interest in the subject, but who has no special theory to defend, may help to define the issues and to show how far the arguments adduced on each side influence a reader who had no previous bias. Far be it from me to pose as a judge or arbitrator. I only wish to write from the "intelligent public" point of view.

As Mr. Mellard Reade opened the present discussion, I take his arguments first, and three of them seem to be strong points:—

1. The universal sandiness of the Lower Trias. Considering that the deposit rests on and against Carboniferous Limestone, Millstone-grits, Coal-measures and Permian rocks, it is curious that pebbles derived from these rocks should be so rare in the Triassic conglomerates; where too has all the shaly material from the Carboniferous series gone to? These questions are greater difficulties on the fluviatile than on the marine hypothesis. Prof. Bonney does not attempt any actual explanation, but only cites analogous cases from the Alpine regions.

2. The existence of Lower Trias sandstone in the vale of Clwyd, a valley that drains from south to north, is admitted as a difficulty by Prof. Bonney.

3. The greater thickness of the pebble-beds in the midland counties and the diminution in the size of the pebbles toward the north. This is certainly a valid argument against the theory that the pebbles have been brought from the north, and so far as I am aware it has never been fully met by Prof. Bonney.

Let us now turn to the three points adduced by Prof. Bonney in the Geol. Mag. for February as adverse to Mr. Reade's view; and of which, by the way, only one is discussed in Mr. Reade's rejoinder.

1. The strength of the marine currents necessary to move large pebbles in water of any depth. This is partially met in Mr. Reade's reply, but the facts he quotes are not very convincing, and Mr. Hunt's letter in the same number challenges the accuracy of his inferences. The idea that the deep valley-like trench in the Irish

Sea has been excavated by the tidal scour is surely a complete assumption; by many it is regarded as an ancient submerged valley.

2. If the waters of the Lower Trias were marine, Prof. Bonney naturally asks in which direction they communicated with the open sea? The group thins out both northward and southward, and it is also doubtful whether there was any connection between the eastern and western basins at this period. The Bunter beds are thickest in North Cheshire, and if there was any communication with the open sea, Mr. Reade must be prepared to bring in the Atlantic either through St. George's Channel or the North Channel.

3. The question—Could such thick pebble-beds be accumulated on a sea floor?—is certainly one which requires an answer, and has not been answered by Mr. Reade.

To sum up, it seems to me that each advocate has one strong point which has not been met by his opponent, and that one or the other of these difficulties must be explained before either theory can be accepted as geological history.

If the pebbles were brought from Scotland in Triassic times, as Prof. Bonney believes, how did the largest pebbles get spread out into a conglomerate 90 feet thick at that end of the basin which would be farthest from the source of the river?

If on the other hand we are to entertain the introduction of a Triassic sea, Mr. Reade must not only indicate how its waters gained access to the midland counties, but how such thick beds of pebbles could be accumulated beneath this sea.

With regard to the nut that Prof. Bonney's hammer is expected to crack, I would like to ask why he feels so sure that the pebbles came from Scotland in Triassic rivers, and why they should not have been derived from some still older conglomerate, the remnants of which are now concealed from view. The existence of a breccia at the base of the Bunter conglomerates in Worcestershire is an interesting fact. Are the contents of the breccia all of local origin, or are there quartzites among them?

With respect to the accumulation of pebble-beds, I think Mr. Reade might have asked Prof. Bonney why he need assume that the water was deeper in the south than the north? Triassic levels were not the present levels, and though Prof. Bonney's theory demands a continuous southerly slope, that of Mr. Reade does not, and I fail to see why there must have been deep water over Central England in order to bring tidal waves over the north-western region.

Finally, is there any proof that the pebble-beds were laid down everywhere at the same time, and might not the Staffordshire beds have been originally beaches at the head of a bay, subsequently spread out and distributed by storm waves (not tidal waves) during a somewhat rapid subsidence of the area? Could not submarine pebble-beds of considerable thickness be formed in this way? I am only suggesting an answer to Prof. Bonney's question, and asking for its consideration. I am not adopting it as a theory, for I cannot yet see that there is a single item of positive evidence for the marine origin of the Lower Trias.

VI.—The Culm-measures at Bude, North Cornwall.

By Major-General C. A. McMahon, F.G.S.

MY paper on the Culm-measures at Bude has elicited two communications, from Messrs W. Maynard Hutchings and Alfred Harker, on which I desire to offer a few comments.

I take this opportunity of saying that I am extremely glad to find that the conclusion at which I arrived regarding the impotence of pressure alone to produce metamorphism is in accord with the published views of my friend Mr. J. J. Harris Teall. "Pressure" alone, he states, in a footnote at p. 410 of his valuable work, British Petrography, "produces no effects on rocks—work must be done upon rocks before change takes place." This footnote escaped my memory at the time of writing my paper, or I should have called attention to it.

I now turn to Mr. W. M. Hutchings's letter. He points out that he collected two specimens of Bude rocks "a few inches apart," and after "a close study of very thin portions of slides under high powers," he found acicular crystals, and dark rods of rutile, "perfectly distinct from any bits of that mineral which may have come from older rocks."

I did not notice any rutile in my slices; but whilst I readily accept Mr. Hutchings's assurance that high powers applied to specially thin portions of his slides revealed the presence of rutile, I fail to see how this fact proves that metamorphism has been set up in the Bude rocks.

Mr. Teall has shown[1] that rutile needles occur abundantly in rocks so absolutely untainted with a suspicion of metamorphism as clays; moreover, Mr. Dick found rutile in the Hampstead Sands.[2]

Unless Mr. Hutchings can adduce cogent evidence to prove that the rutile needles in his Bude specimens were formed after the Bude beds were laid down, I think the natural inference is that they were, like the needles of this mineral found by Mr. Teall in his clays, and the crystals in the Bagshot Sands of Hampstead Heath, floated to the spot with the rest of the fine material of which these beds are composed. Mr. Hutchings, it is true, alleges that his slides contain "secondary sericitic mica"; but he does not favour us with any evidence to prove either that the mica is sericite or that it is of secondary origin.

Rosenbusch says, "the optical behaviour" of sericite "is exactly the same as that of muscovite;"[3] and "it is probable that substances of different composition are included under sericite."[4] In J. D. Dana's Third Appendix, sericite is said to be "a massive muscovite, as shown by Laspeyres, who explains the varying results of earlier investigations by the greater or less impurity of the substance examined."

Mr. Hutchings also relies on the presence of crystals of tourmaline,

[1] Min. Mag. vol. vii. p. 201.
[2] Nature, vol. xxxvi. p. 91; and Brit. Petrography, pl. 44, fig. 4.
[3] Microscopical Physiography, by Iddings, p. 265. [4] *Ibid.*

which he states are "quite distinct from the clastic grains of that mineral." I noted in my paper that the specimens of the Bude rocks examined by me contain fragments of schorl (tourmaline) and needles imbedded in quartz grains that may be referred to this mineral. Mr. Hutchings does not explain in what respect the crystals on which he relies are "quite distinct" from the "clastic grains," or whether these crystals are imbedded in or attached to quartz grains or not. If he means that they present idiomorphic shapes, and are not obviously fragments, that fact does not prove that they were formed after the beds that contain them were deposited. I have in my collection minerals showing very perfect crystallographic shapes collected from river sands. Mr. Dick showed the presence, not only of "sharply-edged prisms" of rutile, but of "perfect crystals" of tourmaline in the Bagshot beds at Hampstead.[1] I was at pains to show in my paper that the material of which the Bude Culm-measures is composed did not travel far; that the current which deposited it was very sluggish; and that the granules of which the Culm-measures are built up are not water-worn.

With reference to Mr. Hutchings' remarks on "Hallock's experiments and conclusions, it seems sufficient to observe that so good an authority as the Rev. O. Fisher thought Mr. Hallock's experiments and conclusions sufficiently valuable to quote in the second edition of his "Physics of the Earth's Crust."[2]

I turn now to Mr. Harker's letter. I think the readers of the Geological Magazine are to be congratulated on this interesting and able contribution to the discussion of dynamic metamorphism. Nothing could be more lucid than Mr. Harker's short exposition of the way strains in rock-masses resolve themselves into voluminal compression and shearing. I see no room to differ from Mr. Harker's statement of the principles that govern strains; and in the following remarks my object is to make my own position clear, rather than to criticize his letter.

In my paper on the Bude rocks I expressly restricted my conclusions to the results of "pressure alone." Mr. Harker's remarks, on the other hand, refer to the effects of "(i) uniform voluminal compression, and (ii) certain shears;" that is to say, to the two principal mechanical sources of heat.

To quote from the Rev. O. Fisher's Physics of the Earth's Crust (second edition, p. 2): "Pressure by itself cannot develope heat. That takes place only when some kind of motion, which however slow may be termed "visible," is arrested and transformed into that invisible motion of the ultimate molecules of a body which constitutes heat." On the other hand, the fact that voluminal compression and friction (shearing) are mechanical sources of heat belongs to the elements of physics.

If "pressure alone" cannot develope that form of molecular energy known as heat, it cannot develope those other forms of energy into which heat is convertible.

[1] Nature, vol. xxxvi. p. 91, and plate 44, fig. 3, British Petrography.
[2] Page 172, footnote.

Where there is shearing or voluminal compression, heat is generated, and molecular activity is increased. But the "energy set free" may be small in amount, and may be lost by conduction; and thus, to quote Mr. Harker's words, it is "easy to imagine conditions under which any amount of contortion may be produced without any metamorphism of the rocks so affected."

But there are some geologists who go beyond Mr. Harker, and contend that pressure produces metamorphism even in cases where the rock-masses do not yield to the pressure exerted on them; and where, consequently, there is neither shearing, voluminal compression, or "movements in the rock-masses."

Mr. Harker is under a misapprehension in supposing that I call "in question the researches of M. Spring and others on the physical and chemical changes produced under the action of high pressures." I spoke of M. Spring's experiments as "instructive and valuable." What I call in question is the way Spring's experiments are sometimes applied by others. The net results of M. Spring's experiments are well summarized by Prof. Judd in one of his papers as follows: "The researches of Spring, van 't Hoff, Reicher, and others, have shown the effects of pressure in bringing the molecules of solid bodies sufficiently close to one another for chemical affinity to operate between them." But it is obvious that chemical affinity can only operate when the substances brought into contact with each other are substances which have a chemical affinity for each other. I fail to see that M. Spring's experiments throw any light on what I consider the most important class of metamorphic changes that take place in a rock; namely, *metachemic* changes. When minerals during the progress of metamorphism have simply undergone paramorphic changes, there is little difficulty in accepting the view that these changes may have been brought about by pressure; but, when we have *metachemic* changes, that is to say, when a mineral of one chemical composition is converted into a mineral of a different composition, it is clear that pressure alone cannot account for the change set up. We need in order to explain these changes to call in the aid of some agent, such as water, to carry to the mineral in progress of alteration the chemical elements required which it does not itself contain, and to remove the chemical elements which it has to get rid of in whole or in part. The chemical elements required for the new mineral may exist in other minerals in some other part of the rock, but they need to be extracted from those minerals by one set of chemical reactions, and conveyed to the spot where they are made over to the mineral in progress of metamorphic change by another set of chemical reactions. For these operations we require water or some other agent. This circulating fluid then—water or other—is the active agent in promoting these changes, and all that compression, or shearing, can do is to provide the heat, or other form of energy, necessary to start or facilitate the requisite chemical reactions.

The agency of water, or some other circulating medium, is, as I have said above, necessary to account for metachemic changes; heat,

no doubt, is also needed to aid these changes. Compression is a mechanical source of heat; but is the supply from this source, I would ask, as important as that due to plutonic causes? Mr. Harker admits that "under a comparatively small cover of rocks much of the energy" set free by compression "must be lost by conduction." But would not much of it be also lost in the case of deep-seated rocks? Rocks are bad conductors of heat, but the compression of deep-seated rocks must take place slowly; and as the amount of heat generated by compression would only be proportional to the reduction of volume, would not much of the heat be lost by conduction? Mr. Harker makes his voluminal compression depend upon two factors, namely, lateral and vertical pressure, the latter being dependent on the thickness of the cover. When the cover is thin, the energy set free by the lateral pressure may be lost, he explains, by conduction. But a thick cover is not put on suddenly. The deposition of sediment is a slow operation; and even when lateral pressure is applied after a thick cover has been formed, it would be applied gradually. In the case of rock-masses under the conditions supposed by Mr. Harker, namely, those so deeply buried that the lateral pressure would be balanced by the weight of the cover, I cannot conceive of a sudden generation of heat arising from a sudden arrest of motion of the nature of percussion. The heat due to a mechanical cause must be generated by gradual compression; and where the generation of heat is gradual, the loss of energy by conduction becomes an important element that must not be left out of our calculations.

As a source of energy it seems to me that plutonic heat supplies all we require. The Rev. O. Fisher, in his work already referred to, writes: "We have pointed out that, having regard to such depths as artificial excavations reach, the law of increase is on the whole an equable one, amounting on an average to about 1° Fahr. for every 51 feet of descent, if it be not even slightly more rapid."[1] The temperature that this rate of increase would give us, at the depths to which we may suppose that the rocks with which we are concerned have been buried, seems sufficient for the work of metamorphism without our indenting on dynamic agency for our supply of heat. How, moreover, are we to discriminate between plutonic heat and dynamic heat, and say that this, or that, bit of metamorphic work was done by the energy supplied from a mechanical source alone?

Mr. Hutchings, in his reference to M. Spring's experiments, alludes to the "intermixture of minute particles of minerals in the fine silt of which these Bude rocks and similar strata are largely composed," and adds, "all the crushing and grinding has been done in the gentlest and quietest way, and the resulting material has but to lie and await the pressure." But the point I desired to make in my paper was that though the material has been finely triturated by Nature's pestle and mortar and judiciously mixed together in Nature's laboratory, and although this mixture has sustained enormous

[1] *l.c.* p. 343.

pressure, no results worth speaking of have followed; and the Bude beds, M. Spring's experiments notwithstanding, are still in an "awaiting" attitude. I think these unfortunate rocks have some ground of complaint. They possess, as I have shown, the chemical composition of granite, but though they have certainly suffered many things at the hands of dynamic physicians, they have not been converted into granite; and indeed have not as yet made even a Sabbath day's journey towards that happy goal!

REVIEWS.

I.—The Geology of the Isle of Wight. By the late Henry W. Bristow, F.R.S., etc. Second Edition, revised and enlarged, by Clement Reid, F.L.S., F.G.S., and Aubrey Strahan, M.A., F.G.S. Geological Survey Memoir. 8vo. London, 1889, pp. 349. With Geological Map, Plates and other Illustrations. Price 8*s.* 6*d.*

THE geology of the Isle of Wight has up to the present time been illustrated and described in two official memoirs, not to mention the one-inch Geological Survey Map, and a series of longitudinal and vertical sections. The Memoir on the Tertiary Fluvio-marine Formation, by Edward Forbes, was published posthumously under the editorship of R. A. C. Godwin-Austen, in 1856; the general Memoir on the Geology of the island, by Bristow, was published in 1862, and has long been out of print. For some years Mr. Bristow had been gathering materials for a revised edition of his work, but a re-survey of the island, on the Six-inch scale, made in 1886-87 by Messrs. Reid and Strahan, has enabled them to make so many and important changes in the Memoir, that the work may well be described as a new one.

On glancing at the tables of strata given in the two works, it will be noted that nearly double the number of subdivisions shown on the old map have been marked on the new edition. This is partly due to the mapping of the Recent and Pleistocene Beds. Mr. Strahan, however, has been able to map out the several divisions of the Lower Greensand, Upper Greensand, and Chalk, which were not before distinguished on the map. He points out that the Wealden rocks are separated from the Lower Greensand by a sharply-defined lithological demarcation, accompanied by a palæontological break, and by some erosion. When the name "Punfield Beds" was introduced by Prof. Judd, the true base of the Lower Greensand had not been discovered in the Dorsetshire locality, hence part of the "Punfield Beds" at Punfield was made up of Lower Greensand, while the whole of the group in the Isle of Wight was referable to the Wealden Beds. This inconsistency was shown originally by Mr. C. J. A. Meyer. His observations have been fully confirmed by Mr. Strahan, who gives further particulars of the beds exposed on the Dorsetshire coast, as well as in the Isle of Wight.

The Lower Greensand is now divided as follows :—

Carstone Sand-rock Series	= Folkestone Beds.
Ferruginous Sands Atherfield Clay.	= Sandgate and Hythe Beds.

It is remarked that the Carstone passes up into the Gault, and that the Sand-rock Series passes down into the Ferruginous Sands; while between the Carstone and Sand-rock Series the boundary is somewhat sharply defined, with an appearance even of slight erosion at times, though there is no evidence of an actual unconformity. Considerable interest, however, attaches to this subject, for in other places (as pointed out by Mr. Strahan) the Carstone passes up into the Red Chalk, which partly represents the Gault; while in the Kentish area the upper part of the Folkestone Beds (the zone of *Ammonites mammillaris*) is by some authorities placed rather with the Gault than with the Lower Greensand. Hence it seems probable that the base of the Upper Cretaceous series may ultimately have to be taken to include the Carstone.

With regard to the Gault, while the main mass belongs to the upper division, it would seem that to some extent the lower division is represented palæontologically; some few species have been added to the general list of fossils, but there is room for further detailed work on the palæontology of this formation. The Upper Greensand has been separated into the Malm Rock and Chert Beds; and the Chalk has been subdivided into Chloritic Marl, Middle and Lower Chalk with Melbourn Rock, Chalk Rock, and Chalk-with-flints. The cliff-sections showing the Upper and Lower Cretaceous rocks have been remeasured, and important additions have been made to the illustrative sections.

In the classification of the Tertiary strata, we find some changes introduced. The name Headon Hill Sands is (provisionally) employed in preference to Upper Bagshot Sands, because they probably belong to a higher zone than the Upper Bagshot Series of the London Basin. They are overlain by the Headon Beds, which form the base of the Oligocene division (or Fluvio-marine Formation of Forbes). For the uppermost portion of this division the name Hamstead Beds is now adopted instead of the "Hempstead Series" of Forbes, as the former is the mode of spelling used in the Isle of Wight. Mr. Reid has proved that these beds extend over a much larger area in the island, and have a greater thickness, than was formerly supposed. Concerning controversial points, it is remarked that "Forbes's correlation is followed in this Memoir, for though there are some minor points on which Prof. Judd's criticisms are no doubt just, yet with regard to the main difference the recent re-examination of the island and mapping of the beds on the scale of 6 inches to the mile have not supported Prof. Judd's contention, but rather shown that Forbes's correlation must still be accepted."

Many additions and corrections have been made by Mr. Reid to the accounts of the Tertiary strata and to the sections illustrating them; and an account of the Flora of the Pipe-clay in the Lower

Bagshot Beds of Alum Bay has been contributed by Mr. J. Starkie Gardner, who thus revises the work done previously by Dr. P. De la Harpe and Mr. J. W. Salter.

The superficial deposits are now described much more fully than previously. They include the Angular Flint Gravel of the Chalk Downs, which is in part a sort of "Clay-with-flints," without much clay, representing the insoluble residue of a great thickness of Upper Chalk. It contains also flint-pebbles, grains of quartz, and other rocks. There are also Plateau Gravels, probably of Glacial age; and Valley Gravels and Brick-earth of later Pleistocene age, that yield remains of Mammoth, Rhinoceros, and Palæolithic Implements. Recent deposits of Alluvium and Peat, Blown Sand, etc., are duly described.

An interesting chapter on Faults and Disturbances gives us an account of the remarkable folds in the strata, and of the occurrence of thrust-planes or slide-faults. The double anticline of the Isle of Wight is one of a series that occurs in the south and south-east of England, traversing the country in an easterly and westerly direction, and having a steeper inclination on the north side. It is remarkable that the same features characterize the folds in the older rocks of the Mendip Hills.

Messrs. Reid and Strahan point out that in the Isle of Wight the sudden downward plunge of the beds on the north side of the anticline seems to be the first stage in the formation of a thrust-plane or slide-fault, and on the neighbouring coast of Dorsetshire, an actual thrust-plane is seen in the Chalk, and this was described and figured by Thomas Webster in 1811 (in Englefield's Isle of Wight). As pointed out, the date of the great movements may be assigned approximately to the Miocene period.

An interesting, but very brief chapter on Physical Geography, deals with the origin of the leading physical features. It is shown that the lines of drainage were determined by the anticlines and synclines which form so marked a feature in the geology; and that while these lines have been maintained, the form of surface due to the original movements has been lost.

The subject of the separation of the island from the mainland is very briefly alluded to, and we hope in a third edition, it may receive due attention, when some reference may also be made to the remarks of the Rev. W. Fox and of Dr. John Evans on this interesting topic.

The final chapter deals with the Economic Products; and the Appendices include Tables of Fossils, Accounts of Wells Sections, and Bibliography.

II.—The Bala Volcanic Series of Caernarvonshire and Associated Rocks. Being the Sedgwick Prize Essay for 1888. By Alfred Harker, M.A., F.G.S. (Cambridge University Press, 1889.)

THE examiners for the Sedgwick Prize at Cambridge have done good service to petrography in opening up the igneous rocks of Caernarvonshire to investigation. Mr. Harker, the winner of the

prize, has published the substance of his essay, illustrated by three small scale and three large scale maps.

The introduction divides the county into three areas; two lie east and west respectively of the Llyn Padarn ridge, while the other includes the Lleyn peninsula. A bibliography is appended.

There are five main outflows of rhyolitic lavas, whose limits are traced on a map which enables the author to suggest that the intrusive masses near Y Foel Fras and that of Mynydd Mawr are their centres of eruption. A few, but too few, analyses of the rhyolites are given, and these indicate the presence of the following minerals, in order of abundance—quartz, orthoclase, albite, pinite, and magnetite. The usual structures are crypto-crystalline and micro-crystalline, but a remarkable type from the lowest lavas is of the nature of an ophitic structure, in which quartz encloses felspars; something similar to this was observed by Teall[1] in the rock of Penmaenmawr. Fragmental and quasi-fragmental rocks seem to be much less common than is usually supposed. In a chapter on the nodular felsites Mr. Harker comes to the general conclusion that the structures arise from solid spherulites, in which either the centre has been replaced by amorphous silica or the shrinkage due to molecular re-arrangement has formed concentric cracks along which alteration has proceeded.

The acid irruptive masses are usually augite granophyres, such as those of Y Foel Fras, and granite porphyries generally augitic, like the intrusions of the Rivals, and occur as cylindrical necks or laccolites. Hornblende is often absent from these rocks; the well-known dark patches are of concretionary origin.

In the description of the intermediate rocks that from Penmaenmawr receives still another name, "bronzite bearing quartz dolerite," and the augite and bronzite andesites of the Lleyn are investigated; most of the latter appear to be intrusive, though conclusive evidence is not given, while there are certainly some andesites associated with agglomerates and ashes.

The adoption of the word "sill" for the intrusive diabase sheets is devoutly to be wished for; such sills are known to be very commonly intruded between the beds of the other volcanic rocks, and, with the doubtful eruption of Porth-Dinlleyn, the diabases are never in the form of lava-flows. The absence of dykes is significant, and the few exceptions appear to be later intrusions injected into the post-Carboniferous joint system. The sills have probably been intruded into cavities or planes of weakness formed during the folding of the strata. Olivine is absent even from the post-Carboniferous intrusive rocks.

After a chapter devoted to the altered gabbros, picrites and hornblende diabases of the Lleyn, the author gives a general review of vulcanicity in Caernarvonshire. A map elucidates the distribution of the cleavage-planes, and makes it quite clear by the increase of contortion and the perfection of cleavage that the pre-Cambrian mass of felsite near Llyn Padarn had a large share

[1] Teall, British Petrography, p. 273.

in resisting the south-easterly thrust to which these structures are due, and that it has even operated in the formation of the phyllites of the "Llanberis slate zone," while it has sheltered the region to the north-west from cleavage and intrusion. The western district, being less affected and not possessing a resisting mass, has lagged behind the eastern, so that faulting and dynamic changes in the diabases have taken place about the junction region of Tremadoc. The foci of the main eruptions bear a relation to this thrust, and are found along a line to the south-east of, and parallel to, the Llyn Padarn ridge, indicating that the thrusting had begun before the vulcanicity.

The eruptive material, if of intermediate character to begin with, seems to have segregated before eruption occurred, so that the lavas are of acid character; the diabases on the other hand, owing to their density, were intruded as sills at lower levels, possibly in part during the main vulcanicity, but also and chiefly after the surface flows ceased; still later and lower are found the ultrabasic intrusions.

In this work we have a very large amount of observation and inference which will form a most useful groundwork when the district is studied minutely and mapped in detail, and then only can its deeper and more complicated problems be unravelled.—W. W. W.

III.—Memoirs by Robert Kidston, F.R.S.E., F.G.S.

1. On the Fossil Plants in the Ravenhead Collection in the Free Library and Museum, Liverpool. Trans. Royal Soc. Edinburgh, 1889, vol. xxxv. pp. 391–417, pls. i. ii.
2. On some Fossil Plants from Teilia Quarry, Gwaenysgor, near Prestatyn, Flintshire. Trans. Royal Soc. Edinburgh, 1889, vol. xxxv. pp. 419–428, pls. i. ii.
3. Additional Notes on some British Carboniferous Lycopods. Ann. Mag. Nat. Hist. 1889, pp. 60–67, pl. iv.

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marine shells. Several of these plants were collected by Mr. E. B. Luxmoore, who generously gave his best examples to the Geological Department of the British Museum, the chief of which are here described and figured. They mostly belong to the order *Filicaceæ*, one being described as a new species, viz. *Sphenopteris Teiliana*. The elegant form of *Adiantides antiquus*, Ett., is recorded as a rare species from Britain. The geological notes to this paper are taken from the works of Mr. G. H. Morton.

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A large amount of literature is quoted throughout the papers, but the absence of dates to the majority of the references is strongly noticeable. Unless accuracy is attained in this section of Palæontological work, synonymy will be difficult to prove or understand. The plates are very valuable, the figures having been drawn with careful detail and precision by the author himself. R.B.N.

IV.—A Catalogue of British Fossil Vertebrata. By Arthur Smith Woodward, F.G.S., and Charles Davies Sherborn, F.G.S. 8vo. pp. xxxv. 396. (London, Dulau & Co., 1890.)

NEARLY six-and-thirty years have elapsed since the late Prof. John Morris published the second edition of his well-known and still-useful *Catalogue of British Fossils;* being the latest in which all known species of British fossil Vertebrates are recorded; and necessarily its information falls short of the requirements of to-day; much having been achieved in the meantime in discovery, description and illustration of new forms, and also in revision and re-description of many of the earlier described species.

We therefore welcome the present volume as supplying a long-felt want. And the authors are to be congratulated on its inception, careful preparation, and its issue as a distinct publication. Its usefulness and merits will be fully recognized by all workers in this division of palæontological science. In respect to fulness of reference to the bibliography, number of localities cited, the amplitude of the synonymy and other information relating to the group, the Catalogue is the most comprehensive hitherto produced. The labour of research and compilation has been great, and pursued with persevering assiduity; in many cases the earliest notices of discovery of vertebrate remains, prior to that of specific description, have been traced and quoted. The nature of the specimens that form the types of species are stated; and when ascertainable, their present location, whether in private or public collections. References to the literature are not restricted to the publications in which the respective species were first described, but numerous original works and memoirs by specialists and other writers of acknowledged authority are also quoted.

As regards the nomenclature, with a few exceptions, the emenda-

in resisting the south-easterly thrust to which these structures are due, and that it has even operated in the formation of the phyllites of the "Llanberis slate zone," while it has sheltered the region to the north-west from cleavage and intrusion. The western district, being less affected and not possessing a resisting mass, has lagged behind the eastern, so that faulting and dynamic changes in the diabases have taken place about the junction region of Tremadoc. The foci of the main eruptions bear a relation to this thrust, and are found along a line to the south-east of, and parallel to, the Llyn Padarn ridge, indicating that the thrusting had begun before the vulcanicity.

The eruptive material, if of intermediate character to begin with, seems to have segregated before eruption occurred, so that the lavas are of acid character; the diabases on the other hand, owing to their density, were intruded as sills at lower levels, possibly in part during the main vulcanicity, but also and chiefly after the surface flows ceased; still later and lower are found the ultrabasic intrusions.

In this work we have a very large amount of observation and inference which will form a most useful groundwork when the district is studied minutely and mapped in detail, and then only can its deeper and more complicated problems be unravelled.—W. W. W.

III.—Memoirs by Robert Kidston, F.R.S.E., F.G.S.

1. On the Fossil Plants in the Ravenhead Collection in the Free Library and Museum, Liverpool. Trans. Royal Soc. Edinburgh, 1889, vol. xxxv. pp. 391–417, pls. i. ii.
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We therefore welcome the present volume as supplying a long-felt want. And the authors are to be congratulated on its inception, careful preparation, and its issue as a distinct publication. Its usefulness and merits will be fully recognized by all workers in this division of palæontological science. In respect to fulness of reference to the bibliography, number of localities cited, the amplitude of the synonymy and other information relating to the group, the Catalogue is the most comprehensive hitherto produced. The labour of research and compilation has been great, and pursued with persevering assiduity; in many cases the earliest notices of discovery of vertebrate remains, prior to that of specific description, have been traced and quoted. The nature of the specimens that form the types of species are stated; and when ascertainable, their present location, whether in private or public collections. References to the literature are not restricted to the publications in which the respective species were first described, but numerous original works and memoirs by specialists and other writers of acknowledged authority are also quoted.

As regards the nomenclature, with a few exceptions, the emenda-

tions of recent authors are generally adopted. Consequently there are many changes, both of the earlier and of later names; and some of these innovations certainly smack a little of the pedantic. A long-established and universally-adopted name is not readily supplanted by one of obscure origin, in obedience to some arbitrary rule of priority, either in the labelling of collections or insertion in text-books. In support of this contention, we note the substitution of *Microtus* for the long-known and familiar genus *Arvicola*: the first name having, it is said, a few months' priority of publication in a comparatively unknown work. The latter name, however, has been recognized by all British and European naturalists dating from the commencement of the century to the present time; and is found in all works on natural history, and palæontological text-books, where its species are referred to. There is nothing to be gained, scientifically or otherwise, by disturbing a name so long and generally accepted by the best writers on the Mammalia. However, these innovations cause no inconvenience, for the discarded names are readily found by cross-references placed in their due alphabetical sequence in the text. The synonymy is copious, and far exceeds in number the names accepted as valid; and much pains have been taken to trace every appellation a species has borne.

The stratigraphical position, and all well-authenticated localities whence derived, are given with each species. To some of the Pleistocene mammals the number appended is overwhelming; for instance, nearly two hundred places in Great Britain and Ireland are cited where remains of *Elephas primigenius* have been found.

It is no exaggeration to assert that, as regards its special subject, no such aid to lighten the labour of research for authorities and other particulars relating to it has ever been prepared for the benefit of vertebrate palæontology, and the book should find a place in every good reference library.

The Catalogue has also the merit of being the first compilation exclusively devoted to one natural division of our extinct fauna published in distinct form; and initiates a departure from the older method of inclusion in one work of all the various classes; and the same plan might be adopted with equal advantage for other palæontological groups.

It is matter of interest to note how much has been accomplished in advancing our knowledge of the British Fossil Vertebrata since 1854, the date of Morris's Catalogue; and the present work will, approximately, enable us to do this. Morris enumerates 350 genera of all classes of vertebrates, comprising 960 named species, and 35 unnamed as being then known. He gives few synonyms, and the localities cited seldom exceed one to a species; the whole occupying 48 pages of the Catalogue. But in the mean time more than 200 of these species have been merged in others, and have disappeared from our lists, the names only being found in the long roll of synonyms. These, therefore, have to be deducted from the total of the species then considered valid, thus reducing the number, as now accepted, to 760.*

* Species referred to *Ichnites* are not included in the above numbers.

In the work before us 662 genera are enumerated, containing 1534 species recognized as well founded, and 54 not specifically determined. The figures quoted show that about 800 new forms have been added to our extinct Vertebrate fauna since 1854; a fairly large number, having regard to the comparatively small area of the British Isles. But these new species only represent a portion of the large number actually described in the interval; for many, as a result of subsequent examination, or the acquisition of new evidence either by their authors or other palæontologists, have been incorporated with species previously established. The voluminous and valuable descriptive literature relating to them is distributed in many works specially devoted to the subject; Transactions and Journals of numerous scientific societies—metropolitan and provincial—and publications devoted to science, that it is difficult without the assistance of a system of comprehensive reference, such as the writers of this Catalogue have produced, to realize how extensive it is.

To have rendered their work absolutely complete as one of ready reference, the authors should have inserted a list of Families with the genera appertaining to each. A list of this description would be of immense service to many curators of provincial museums, and also to others having a general knowledge of one or more of its classes. So many revisions of the earlier—and also of some of the later—families and genera have been made by specialists, that without a library containing all recent memoirs relating to the subject at hand, it becomes difficult to ascertain their systematic position.

It is with reluctance we direct attention to this omission—probably an oversight—but it can be easily rectified in a future edition; and will add still further value to this already most valuable work.

REPORTS AND PROCEEDINGS.

Geological Society of London.

March 26, 1890.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On a new Species of *Cyphaspis* from the Carboniferous Rocks of Yorkshire." By Miss Coignou, Cambridge. Communicated by Professor T. McK. Hughes, M.A., F.R.S., F.G.S.

The author describes a fairly perfect head of a Trilobite found in the Pendleside limestone of Butterhaw, near Cracoe, which appears to belong to the genus *Cyphaspis*, though it differs from the typical species of that genus in possessing two pairs of glabellar lobes. The name *Cyphaspis* is proposed for this form.

2. "On Composite Spherulites in Obsidian from Hot Springs, near Little Lake, California." By Frank Rutley, Esq., F.G.S., Lecturer on Mineralogy in the Royal School of Mines.

The spherulites which form the subject of the present communication have been previously noticed, and it was then suggested that a

smaller spherulitic structure was set up in the large spherules after their formation. In the present paper evidence was adduced in favour of a different mode of origin. It was argued that the small spherulitic bodies (primitive spherulites) were developed in the obsidian before it assumed a condition of rigidity, and that they floated towards certain points in the still viscid lava, and segregated in more or less spherical groups, though there is no evidence to show what determined their movements; furthermore, that from a point or points situated at or near the centre of each group, crystallization was set up, giving rise to a radiating fibrous structure, which gradually developed zone after zone of divergent fibres until the entire mass of primitive spherulites was permeated by this secondary structure—a structure engendering a molecular rearrangement of the mass, such as would obliterate any trace of structure which the primitive spherulites might have originally possessed.

In a supplementary note the views of Mr. J. P. Iddings with reference to the spherulites in question were given. Mr. Iddings considers that the structures here described as primary are of secondary origin. The author stated in detail his reasons for adhering to the conclusions given in this paper.

3. "A Monograph of the Bryozoa (Polyzoa) of the Hunstanton Red Chalk." By George Robert Vine, Esq. Communicated by Prof. P. Martin Duncan, F.R.S., F.G.S.

The fossils examined occurred on tests of Echinoderms and on the shells of *Terebratula biplicata*, *T. capillata*, Oysters, *Inocerami*, *Nautili*, and Ammonites. The best of the forms of *Diastopora* and *Proboscina* are found on *Inocerami* and Ammonites, but the most abundant individuals are *Stomatoporæ*, chiefly on *Terebratula biplicata*. Species of *Entalophora*, *Idmonea*, and "*Ceriopora*" are very rare or badly preserved, and Chilostomatous forms are also very rare.

In the present monograph the author felt obliged to limit or re-define the generic terms employed, and proceeded to describe in detail the forms which he has examined from the Hunstanton Red Chalk and other Cretaceous deposits, including the following new forms:—*Proboscina irregularis*, *P. uberta*, *P. gracilis* ?, var. *Reussi*, *P. claviformis*, *P. hunstantonensis*, and var. *ampliata*, *P. Jessoni*, *P. gigantopora*, *P. dilatata*, var. *cantabrigiensis*, *Diastopora hunstantonensis*, *D. fœcunda*, *D. Jessoni*, and *Membranipora gaultina*.

4. Evidence furnished by the Quaternary Glacial Epoch Morainic Deposits of Pennsylvania, U.S.A., for a similar mode of formation of the Permian Breccias of Leicestershire and South Derbyshire." By William S. Gresley, Esq., F.G.S.

The author noted that nodules of ironstone occurring in the Pennsylvanian glacial deposits of Quaternary age are scratched in precisely the same manner as those which he has described from the Permian deposits of Leicestershire and Derbyshire, and concluded that one and the same agency, viz. ice, has been instrumental in producing the observed results in both cases.

CORRESPONDENCE.

ON THE SUPPOSED PECTORAL LIMB IN *COCCOSTEUS DECIPIENS*.

Sir,—Permit me a few words in reply to Prof. v. Koenen's most courteous remonstrance concerning the supposed pectoral limb in *Coccosteus*.

Although I did indeed suggest that Prof. v. Koenen may have mistaken the outer margin of the interlateral plate in his *C. Bickensis* for a pectoral spine, I did so without dogmatism; and when I have the opportunity of examining the German specimens, I shall do so with a mind perfectly open to conviction.

But I stand firm as regards the position which I have taken up as regards the absence of any such "Ruderorgan" in *Coccosteus decipiens*, the type of the genus; and I do not think that the argument upon which Prof. v. Koenen bases his expectations of its ultimate discovery in this species, carries any weight whatever. When we take into account the position in the head of the sclerotic ring, its delicacy, and the manner in which the Scotch specimens are crushed, it is by no means astonishing that this structure should be so rarely observable in *Coccosteus decipiens*. Far otherwise would be the case with a pectoral limb, were such a thing present,—for it is simply incredible that a *long stout prominent external* appendage, like the "Ruderorgan" in Prof. v. Koenen's restored figure, should have escaped preservation in the hundreds and hundreds of specimens of Scotch *Coccosteus*, which are to be found in the museums of this country, many of which are absolutely entire from the tip of the snout to the point of the tail.

I cannot therefore share Prof. v. Koenen's expectations as to the future discovery of a pectoral limb in *Coccosteus decipiens*, and consequently must still maintain that if such a limb is really present in *C. Bickensis*, v. Koenen, that species must be removed to a new genus.

7th April, 1890. R. H. Traquair.

MR. MELLARD READE ON THE PHYSIOGRAPHY OF THE LOWER TRIAS.

Sir,—So kindly is the tone of Mr. Mellard Reade's reply to my criticisms on his explanation of the Physiography of the Lower Trias that it is not without regret that I am compelled to observe that in my opinion he has failed to meet them. His reply, in short, as it seems to me, errs in excess and in defect. In excess, for these reasons:

(1) I do not "misconceive the facts in speaking of the Bunter generally as a 'conglomerate.'" Mr. Mellard Reade has misunderstood my words by isolating my last paper from all that I have previously written. I have touched upon the anomaly of the Lancashire Bunter (of what I know something) twice at least (Geol. Mag. Dec. II. Vol. X. p. 204: Address to Sect. C, British Association, Birmingham, 1886). I did not again mention it, because I had nothing to add to my previous remarks. In reading the proof the

idea of inserting a protecting clause did indeed occur to my mind, but I abstained from so doing, because I supposed that I should be credited with the possession of what is common knowledge. Readers get wearied if, in writing geological papers, we imitate the style of legal documents. I dwelt upon the thickness of the Staffordshire pebble beds (which I understated rather than overstated), because the strength of a chain is the strength of its weakest link, and I cannot explain, for reasons already given, these conglomerates, as they occur over a considerable area of the Midlands, by Mr. Mellard Reade's hypothesis. The comparative absence of pebbles in the northern region is undoubtedly an anomaly for which we have not yet found the explanation (I could offer one, but, as it would be an hypothesis, I abstain on the present occasion, lest I should trespass too much on the Editor's tolerance). But on the hypothesis of a southern derivation, the much greater thickness which the Bunter group as a whole attains in the district about the Mersey compared with that in Staffordshire (more than double) is also an anomaly. To this I believe we might add—though here, as my personal observations are not very numerous, I must speak with caution—the greater abundance of felspar fragments in the sandstones of the Lancashire-Cheshire Bunter. So in this matter, as it appears to me, our difficulties are mutually destructive, like Kilkenny cats, and they may leave us much as they found us.

But I cannot understand how the nature of the sand in the Bunter helps Mr. Mellard Reade. "An inspection of the geological map of Scotland shows such a diversity of rock structure, and there exist such lithological differences in the various areas that would have drained into these two hypothetical rivers, as to seem irreconcilable with the required travel of sand southwards." This inspection, as it seems to me, shows that the area chiefly drained would be the great crystalline region—then doubtless more Alpine in character than now, the fragments of which are called the Scotch Highlands. Mr. Mellard Reade forgets that the detrital beds of this region (which were doubtless also undergoing denudation at this epoch) present no small resemblance to the Bunter Beds of England. Parallels to this argument may be found in the sandstones of the Carboniferous system in England, and in not a few cases in other lands.

(2) Mr. Mellard Reade falls into a second, though perhaps more natural, misconception in regard to my views as to the efficacy of tidal currents. My doubts as to their potency referred to their action *under the physical conditions of the English Trias;* that is, in an elongated gulf (adopting for a moment his hypothesis), to which, moreover, in all probability, the entrance was narrow and shallow. To discuss the whole question would extend this letter too much, but I must remark that citations concerning the action of the tide off the British Isles, where the physical conditions are very dissimilar, do not appear to me germane to the subject.

Next, as to the defect. Mr. Mellard Reade refrains from noticing my comparison of the Bunter of England to the Nagelflue and

Molasse of Switzerland, because "he has no personal observations to record" on them. But is not this in effect admitting that he is making wide generalizations on a rather limited experience, or, in other words, falling into an error too common among British geologists? But still more serious a defect is his silence as as to my main argument, which briefly stated is this: "I think I have a fairly good knowledge of British rocks; I can identify the majority of the Bunter pebbles (not of one rock species only) with rocks which occur *in situ* in the Highlands and as pebbles in later Palæozoic beds in Scotland down at least as far as Arran, but I have as yet failed to find them, either *in situ* or in older conglomerates in the southern half of England, or to discover a spot in which we may assume them to be hidden from our sight."

T. G. Bonney.

OBITUARY.

FRIEDRICH AUGUST VON QUENSTEDT.

Born 9th July, 1809; Died 21st December, 1889.

By the death of Prof. Quenstedt, Science has to mourn the loss of the Nestor of German geologists. He was born at Eisleben in Saxony, and after the death of his father, a member of the Gendarmérie of that town, he was adopted by his maternal uncle, a schoolmaster at Meisdorf; here he learnt Latin and music, and by the latter accomplishment managed to earn sufficient money to go to a University. He went to Berlin in 1830, and having overcome his uncle's wish that he should devote himself to theology, Quenstedt threw himself into the study of natural science and philosophy; he worked especially at crystallography and mineralogy under Wiess and Mitscherlich. After the conclusion of his University course, Quenstedt was appointed an Assistant in the Berlin Museum: his two principal papers published at this time were "Ueber Afterkrystalle des Serpentins" and "Die Entwickelung und Berechtung des Datholiths." In 1837 he was appointed Extra Professor at Tübingen, and in 1842 he was promoted to the full Chair of Geology, Mineralogy, and Palæontology. Here he laboured for more than fifty years, investigating the palæontology and geology of Würtemberg, building up the collection of the University, and popularizing the study of geology in the neighbouring district. That the last object was not the least in Quenstedt's ambition is illustrated by the fact that the first work he published in his new home was a small popular volume, "Schwaben, wie es war und ist." Immediately after his appointment at Tübingen, Quenstedt began the work on the Suabian Jurassics, with which his name will always be associated. His "Flözgebirge Württembergs" (1843) was the first fruit of his labours in this field. In order to compare this series with that of other areas, Quenstedt made a number of walking tours in France, North Italy, Savoy, etc. A serious illness of the lungs in 1859, due to over-exposure, compelled him to abandon these annual excursions; he had however already acquired the knowledge he sought, and his "Der Jura" had appeared in the previous year.

The "Petrefactenkunde Deutschlands" was Quenstedt's greatest work; the first volume was issued in 1849, and the eighth and last in 1884: it has been calculated that there are no less than 19,029 specimens figured and described in this work. Jurassic palæontology is especially well treated in the Petrefacta, and also in Quenstedt's "Handbuch der Petrefaktenkunde," the three editions of which appeared in 1852, 1867, and 1885 respectively; he made further contributions to the knowledge of the fauna of the same system in an extensive series of memoirs. The Cephalopoda was his favourite group: it formed the subject of both his first and last palæontological works, viz. his doctoral thesis in 1836, "De notis nautilearum primariis," and "Die Ammoniten des schwäbischen Jura," concluded a few months before his death. But though palæontology became the chief work of his life, as was naturally the case with a geologist living among the rich Jurassic rocks of Würtemberg, Quenstedt did not neglect his first love, mineralogy, and his "Methode der Krystallographie" (1840), his well-known "Handbuch der Mineralogie" (1854, 1863, and 1877), and his "Grundriss der bestimmenden und rechnenden Krystallographie" (1873), were his principal publications upon this subject. Probably no German geologist was more prolific of big books than Prof. Quenstedt, and the fact that he accomplished so much is no doubt to be explained by his retention in after-life of the indefatigable energy, the simple life, and abstemious habits, which characterized him in his student days. Born of the people, he was always in touch with them, and he never used the title "von," which had been granted him; his popular works, "Sonst und Jetzt" (1856), "Epochen der Natur" (1861), and "Klar and Wahr" (1872), showed how deeply he felt the need of the popularization of scientific education. His success in forming so valuable a collection from the Würtemberg Jura is probably as much due to the interest in geology spread by his writings as to his own personal popularity with the people among whom he lived so long and laboured so well.

MELCHIOR NEUMAYR.

Born 24th October, 1845; died 29th January, 1890.

Melchior Neumayr was born in Munich on 24th October, 1845, but spent most of his childhood in Stuttgart, where his father was the Bavarian Ambassador. As the son of a family that has borne an honoured name in the annals of Bavarian history, Neumayr was destined for political service, and after leaving the Gymnasium of Munich, he commenced a course of legal studies in the University of that city. Here, however, his enthusiasm for science manifested itself, and led him to abandon law for geology and palæontology, the better to study which he proceeded to Heidelberg. After gaining his Ph.D. at this University, he returned to Bavaria, and worked under Gümbel on the geological survey of that state. After a few months' training he joined in 1868 the service of the Austrian Geologische Reichsanstalt as a volunteer; in the same year

he issued his first paper in conjunction with Dr. Guido Stache on "Die Klippen bei Lublau und Jerembina." He soon secured an appointment on the paid staff of the Survey, on which he remained till 1872. He was engaged mainly in the Tyrol, the Vorarlberg, and the Carpathians, and it was no doubt the work during this period that fixed the bent of Neumayr's genius, as, after facing for four years the great geological problems connected with those districts, it was impossible for him to settle down as merely a laboratory palæontologist. At the same time Neumayr was not indifferent to the mountains for their own sake: he soon became a keen climber and an energetic member of the Deutscher und Oesterreich Alpin Verein; in spite of the many calls upon his time, he served for a year as secretary to this, the greatest of the Alpine Clubs, and only withdrew from the rolls of officers on his return to Germany in 1872. Though in later years heart disease prevented his active participation in Alpine work, he followed it with unflagging interest, and was to the last a fairly regular contributor to the Mittheilungen of the Deutscher und Oesterreich Alpin Verein.

In 1872 Neumayr resigned his post on the Austrian Reichsanstalt, and returned to Heidelberg; but in the succeeding year he was recalled to Vienna as Extraordinary Professor of Palæontology, a chair then created. In 1874 he made a geological excursion to Northern Greece and the Ægean; he climbed Athos and Olympus, and worked out and described the sequence of schists, gneisses and marbles of which the former mountain is composed. In 1879 he was appointed to the Ordinary Professorship at Vienna, a post he held till his death.

Though Neumayr's scientific work was executed in but little over twenty years, it was unusually fruitful in interesting results. His writings may be divided into three classes: First, his more popular works, such as his well-known "Erdgeschichte" (1887), and some of his papers on mountain structure, such as that recently issued on "Bergstürze." Secondly, his petrographical and stratigraphical papers beginning with his "Petrographischen Studien über mittleren und oberen Lias Wurtembergs" (1868 and 1870), and his "Dogger und Malm in Penninischen Klippenzug" (1869); besides a series on the Jurassic, there are his "Das Schiefergebirge der Halbinsel Chalkidike und der thessalische Olymp" (1876); and a valuable series giving the results of his Ægean tour, published in 1881; later still his paper "Die krystallinischen Schiefergebirge in Attika" (1884), shows that he always retained his interest in petrographical problems.

The papers of the third class, the more strictly palæontological, form a very lengthy list, touching on most divisions of the Animal Kingdom. The groups upon which Neumayr wrote most frequently were the Jurassic Cephalopods and the freshwater Mollusca of the Vienna basin; but valuable papers stand to his credit on the Foraminifera, Cœlenterata, and Echinodermata; his first memoir on the last group, "Morphologische Studien über fossilen Echinodermen," was an especially original and suggestive piece of work. Nor did

he confine himself to the Invertebrates, for he wrote more than once on the Mammalia. Neumayr's knowledge of the Jurassic fauna and geology was exceptionally wide, and upon it was based the brilliant generalizations as to the zoological regions and climatic zones of that period, which mark out the series of papers commenced under the title of "Jura-studien" as his masterpiece. The "Stämme des Thierreichs" was the last of his larger works, and of this only one volume has been issued: in this he dealt with the Protozoa, Cœlenterata, Echinodermata, Vermes, and Molluscoidea, treating each group with a master-hand and in an original method. The second volume would have been even better, for if Neumayr could be charged with being a specialist, it would have been in connection with two of the classes there to have been discussed. He also projected an "Index Palæontologicus"; but this with many other plans of his has been frustrated by his death.

But though it may be convenient to group his work under these three divisions, Neumayr was too true a palæontologist for any rigid classification to be possible on such lines. Palæogeography was with him inseparably connected with palæontology, and his work on the former subject compelled him to keep abreast with the progress in other branches of geological work. Neumayr did not regard palæontology as a mere branch of zoology, and, keen evolutionist though he was, fossils had for him a higher value than that which they possess from their bearing on the origin of the existing fauna. He was, of course, interested in this aspect of the question, and probably no better work has been done in tracing descent among the invertebrates than his "Herkunft der Unionen" and his "Die natürliche Verwandtschaftsverhältnisse der schalentragenden Foraminiferen." But it would be unjust to Neumayr to regard him as a phylogenist alone, or to attach most value to his work in this field: the most original work in his "Stämme" was his reclassification of the Crinoidea, which marked a great advance when the compositor set it up; but it was out of date before the sheets had left the press. His discoveries in other subjects are of much more permanent value, and it is probably for these that he will be best remembered. He has, in fact, been recently described as a "palæogeographer" rather than a palæontologist, but this he would probably have regarded as a slurring limitation on his favourite branch of science. Neumayr's qualifications for the discussion of questions of the physical geography of the past were simply unique, and it is probably here that he will be most missed. Considering the powerful work of his early manhood, still more brilliant achievements might have been expected from the efforts of his maturer years. But the heart disease that had so long afflicted him struck him down in the very prime of life, just when his mastery of Jurassic palæontology, his thorough acquaintance with stratigraphical literature and his sound knowledge of the principles of physical geology, seemed most in demand for the solution of the problems that he knew so well how to handle.